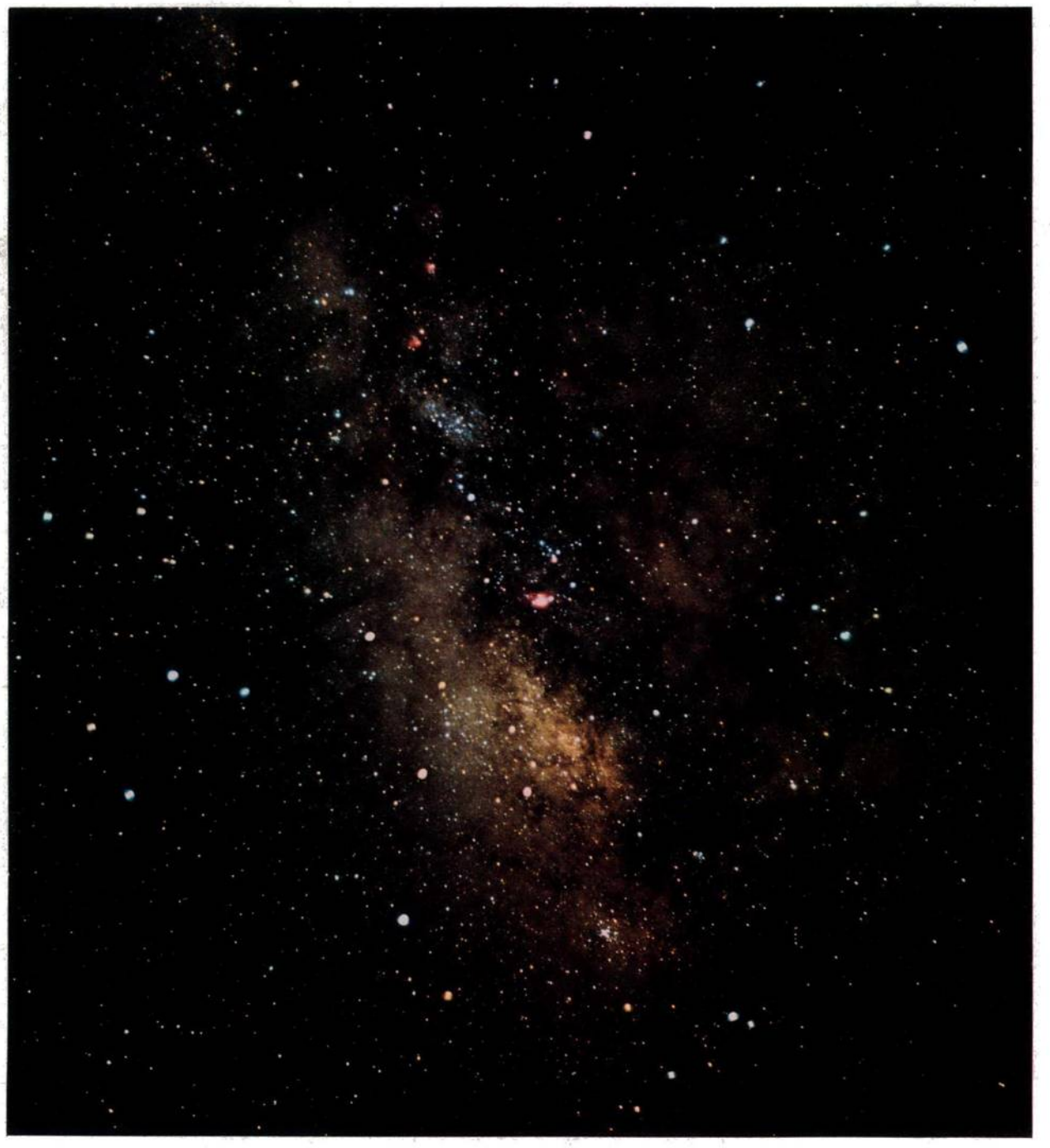
ASTRONOMY

MARCH 1974 $1.50



Cave ASTROLA

RESPECTED NAMES IN ASTRONOMY SINCE 1949

American Made — Nationally Available on Extended Payment Terms.

8"MODEL"B"DELUXE NEWTONIAN —$665

8" DELUXE CASSEGRAIN — $995

For detailed study of the planets, their moons, and other spectacles of the solar system, no instrument can match the cost-performance ratio of the classical Newtonian reflector. The very small size of the secondary mirror in a long-focus Newtonian means high effective aperture and minimum diffraction, for better planetary detail and contrast and for fine double-star resolution. The Newtonian optical system permits use of a convenient Barlow lens to multiply effective focal length for high magnification with comfortable, medium-power eyepieces. The system's classic simplicity results in higher light-gathering power, unmatched visual resolution — more performance for the dollar.

On the other hand, if your interests are in special optics and astro-instrumentation, the Cassegrain configuration is more compact, and its focus location is suitable for a variety of instrument mountings. When equipped with the highest-quality optics, it, too, can be a fine performer for the serious amateur astronomer. Why not consult Cave Optical Company before making a final selection? Our advice is free. We build them all, and our optical department has figured more than 21,000 large optical surfaces. No job is ever hurried at the sacrifice of quality. That's why you can rely on Cave ASTROLA, as amateurs, professionals and industry all have done for many years.

ASTROLA NEWTONIAN REFLECTORS

6"Student	$ 235.00
Student Deluxe	$ 330.00
Model "A"	$ 350.00
Model "A" Deluxe	$ 495.00
8"Lightweight Deluxe	$ 530.00
Model "B" Standard	$ 420.00
Model "B" Deluxe	$ 665.00
10"Standard	$ 535.00
Deluxe	$ 860.00
12-1/2"Transportable	$1350.00
Permanent-Pier Observatory	$2350.00
16"Permanent-Pier Observatory	$3950.00

Exclusive manufacturers and distributors of MAGNUSSON setting circles.

CAVE TELESCOPE MIRRORS
(Includes diagonal and aluminizing)

	New	Refiguring
6"	$ 75.00	$ 45.00
8"	$110.00	$ 63.00
10"	$190.00	$100.00
12-1/2"	$310.00	$160.00
16"	$925.00	$550.00

Eyepieces — $24.50 each
Abbe Orthoscopic Orthostar
26.6, 20, 16, 10, 6.6 mm.

We carry a complete line of telescope parts and accessories.

WRITE TODAY FOR YOUR 1974 COLOR CATALOG.

CAVE OPTICAL COMPANY
4137 E. ANAHEIM STREET
LONG BEACH, CALIFORNIA 90804
Telephone 213-434-2613

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

March 1974 Vol. 2, No. 3

THE COSMIC ABYSS 4
an interview with Kip Thorne

WHAT HAPPENED TO COMET KOHOUTEK? 12

STELLAR FRONTIERS
Magnetic Fields Beyond Earth 19
by Gerrit L. Verschuur

SKY ALMANAC
Spring Begins in Planet-Poor March Sky 24

MARCH STAR DOME 32

ASTRO-MART 36

GAZER'S GAZETTE
In View of Vesta 38

ASTRO-NEWS 45

IN FOCUS 50

PHOTOGRAPHY IN ASTRONOMY
Photography With Small Telescopes 52
by John C. Gorka

CONSTELLATION CLOSE-UP
Leo 58
by Thomas C. Bretl

PUBLISHER'S MEMO 62

Staff

Publisher Editor
Stephen A. Walther

Executive Editor
Terence Dickinson

Managing Editor
Penny Oldenburger

Contributing Editors:
Thomas C. Bretl
John Harmon
John Sanford
Gerrit L. Verschuur

Art Director
Craig McFarland Brown

Art Assistant
David A. Schwartz

Production Supervisors
Ernest K. Baudhuin
William Stanfield

Western Regional Editor/Staff Cartographer
Raymond G. Coutchie

Contributing Artist
Victor Costanzo

Cover
Photograph by Orien A. Ernest

The constellation Sagittarius, just below center in this photo, marks the direction of the nucleus of the Milky Way galaxy. The swarms of stars seen here are all relatively nearby — only a few thousand light-years away. Interstellar dust obscures our view of hundreds of millions of stars farther in toward the core. Right at the galaxy's center is believed to be a mysterious black hole, the subject of "The Cosmic Abyss" beginning on page 4.

Separations prepared by Graphics Unlimited, Inc., Butler, Wisconsin 53007.

Printed by W. A. Krueger Co., Brookfield, Wisconsin 53005.

Typesetting by Grafilm, Inc., Milwaukee, Wisconsin 53208.

Published monthly by AstroMedia Corp., 757 North Broadway, Suite 204, Milwaukee, Wisconsin 53202. Telephone (414) 276-2689. Copyright © 1973 by AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or otherwise copied for public or private use without written permission of the publisher.

Second class postage paid at Milwaukee, Wisconsin.

Direct all subscription correspondence, new subscriptions, change of address and complaints to ASTRONOMY, Circulation Services, 1726 North 1st Street, Milwaukee, Wisconsin 53212. Allow six to eight weeks for address change to take effect.

Cover price, $1.50. Subscription price: 1 year, $12.00; 2 years, $22.00; 3 years, $30.00. Canada and Mexico: add $3.00 per year. All other foreign: add $6.00 per year.

POSTMASTER: When undeliverable, send form 3547 to publisher.

THE COSMIC ABYSS

An Interview with Kip Thorne

Future generations of man venturing beyond the planets to ply the vast spaces between stars will, sooner or later, encounter the most bizarre objects yet uncovered by man's inquisitive mind — the ominous gravitational black holes.

These strange objects, discussed theoretically only a few years ago, have now been observed. No longer theory, the cosmic abyss of a black hole is reality. At least that's the opinion of most astronomers including gravity theorist Kip Thorne of the California Institute of Technology

Matter, torn away from the side of a giant blue star, is accelerated into a fatal cosmic whirlpool and eventually disappears down the abyss of the black hole. The hole, the center of a spiralling ring of intensely hot gas, is the scene of intense X-ray radiation. Earth orbiting telescopes detected the radiation leading to this first identification of a black hole.

Artwork by Victor Costanzo

who says he is "almost certain we have detected the first black hole".

The turning point between possibility and probability came last November when a team of British astronomers using the Copernicus satellite (Orbiting Astronomical Observatory), tied the binary supergiant star system, HDE 226868, to the X-ray source, Cygnus X-1. They believe they detected evidence of the structure of the visible star's gas clouds swirling around and into the X-ray source or black hole.

Cygnus X-1 emits intense X-rays, representing a million times more energy that the total energy output of our own sun. The X-rays come from the immense gravitational field on the edge of the black hole. There the visible star's atmosphere is compressed prior to its complete disappearance into Cygnus X-1 — the black hole.

A black hole is a dead star which has collapsed on itself. Neither light nor matter can escape because of its intense gravitational field. Although it is invisible, the black hole's presence can be detected by X-rays emitted from the extremely hot gases falling into it after being pulled off the visible supergiant star. The visible star could eventually disappear altogether down the black hole leaving no trace of its former existence.

By observing the way X-rays are absorbed as they pass through the visible star's atmosphere, scientists concluded the X-ray object is very small. The mass of the black hole, about five times that of our sun, is known by the way the more massive visible star moves in its orbit. The presence of such an "invisible" star points to only one conclusion: a black hole.

Anything that comes into the gravity "embrace" of a black hole becomes a helpless plummeting speck accelerated to fatal velocities and pressures.

Let's take some future space travellers heading toward, say, the star Aldebaran. They detect an incredibly strong gravity field seemingly attached to no physical object. (It could have once been like Cygnus X-1 but now the black hole has swallowed up its companion star). Trapped in its grip the spaceship is as powerless as a human falling into a bottomless pit. Eventually the craft is crushed out of existence by the immense gravity of this cosmic trap.

Fiction? No, gravitational black holes are as real as the gravity that pulls raindrops to Earth. They are the ghostly tombstones of dead stars — stars that once were far brighter than the sun. Upon reaching maturity their fuel supplies of hydrogen and helium became exhausted, and they died in colossal supernova explosions.

One supernova explosion liberates more energy in a second than the sun does in millions of years. During such cataclysms the outer layers of the dying star are ejected while the core collapses under its own weight. With increasing density the core's surface gravity rapidly escalates until a mass more than five times that of the sun crushes itself out of existence!

Yet the gravity field remains — a cosmic whirlpool of atom crushing strength. Anything that happens to pass by is scooped up and swallowed.

Have we gone past the bounds of human imagination with the discovery of black holes? How can they exist — how can gravity change a star into a bottomless pit? Let's back up a bit and take a look at it step by step.

The molecules and atoms we have here on Earth are made up of large volumes of space flecked with tiny dots of matter. For example, if you were sitting in the top row of a large football stadium, the upper tier of seats would represent the orbit of a marble sized electron. The atom's nucleus would be a BB sitting on the 50 yard line. Everything in between the two would be empty space.

In the interior of stars, matter can be much more dense. When a large star runs out of hydrogen fuel, the immense forces of gravity which have been held at bay by thermonuclear burning within the star suddenly become dominant. As noted theoretical astrophysicist Fred Hoyle puts it, the star has to pay all of its back gravitational taxes at once. The forces of this violent, almost instantaneous collapse are sometimes so great that the electron whizzing around the stadium is driven into the BB sized nucleus on the 50 yard line. The two opposite charges cancel one another to form a neutron. Then under the crushing force of gravity, the entire stadium fills up with marble-like neutrons.

Matter of this density exists in the heavens in the form of neutron stars or pulsars. In effect, pulsars are giant atomic nuclei in which the interatomic spaces of matter here on Earth have been spectacularly reduced by gravitational collapse. We can learn about the structure of matter in such stars from the high energy radiation they emit.

Imagine now a stellar collapse so violent that

Viewed from afar, our own Milky Way galaxy would look similar to this distant megalopolis of stars called M-101. According to Kip Thorne, normal galaxies like this probably have a massive black hole at their core. Since the hole would be only a few million miles across it is invisible, and would remain so even on much closer inspection.

Kitt Peak National Observatory Photograph

the marblelike neutrons themselves are smashed together by the gravitational crush. The matter (or whatever it is) produced by such a collapse is unimaginably dense. The resulting gravitational field is so intense that no light (or any other kind of radiation) can escape. Hence it is called a black hole. If you could shine a flashlight directly on a black hole you would see nothing, for the photons of light would be sucked down its gravitational drain, never to return to your eye.

While black holes cannot be observed directly, their effects on stars unfortunate enough to be near them can be seen as in the case of Cygnus X-1, and probably many other X-ray sources.

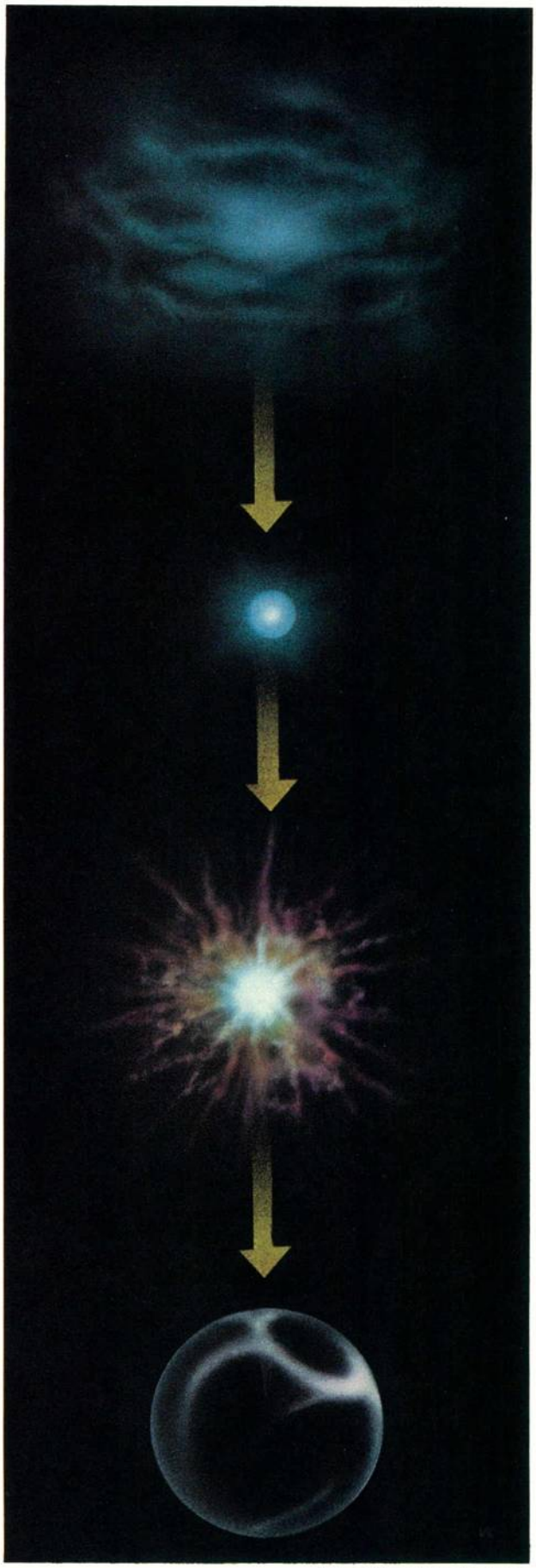
Suppose we have a star at the point in its life when it reaches the critical stage where it can't support itself by release of energy and begins to collapse. How long from that point till it reaches the black hole stage?

If we have a typical very massive star," explains Thorne, "the collapse time may be on the order of a few hours or a few days because the star is so blown up from its previous state of existence — where radiation was continually flowing out through it, keeping it blown up like a balloon — that it takes quite awhile for the collapse to really get started. But once the collapse is going well and the star has contracted to 10 or 20 miles across, it's nearing a black hole state. Thereafter it's only a matter of a fraction of a second till the star is snuffed out and the gaping hole is left in space."

Thorne wishes he knew for sure what types of stars become black holes."It's much easier to answer the question of what kinds of objects can be left behind when a star dies, than to answer the question of which stars will become which kinds of objects," he said.

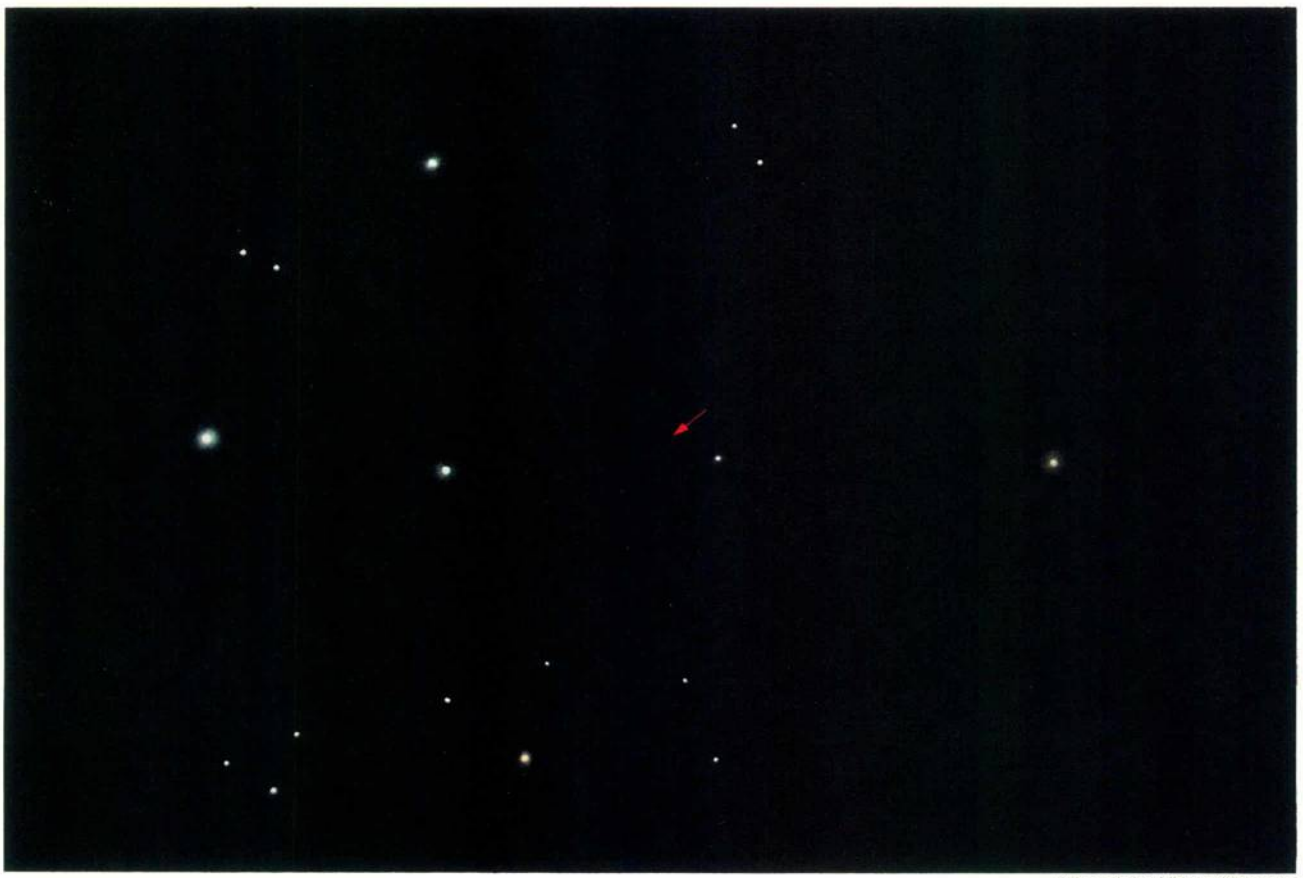
However, his best guess at the moment is that stars which are more than five times heavier than the sun are likely to eventually become black holes. If it were possible to watch such a star collapse inward you would simply see the star shining brightly at first, and then as it starts to snuff out it becomes redder and redder, and darker and darker. Then it's gone.

In reality when such a collapse occurs,



The formation of a black hole seems to hinge on the size of the original star. The top illustration shows a cloud of gas and dust condensing to form a star. The sun was born the same way but here more material was available and a star greater than five times the mass of the sun emerged. Such massive stars "burn" with a bright blue light that consumes their fuel supplies in only a few million years. A complex series of events produces instability in the star's energy production and a violent explosion (supernova) blasts off the outer layers leaving a core consisting of the crushed inner region of the star — a black hole.

Artwork by Victor Costanzo



Artwork by Victor Costanzo

Six thousand light-years away in the cross-shaped constellation Cygnus, the bizarre X-ray object Cygnus X-1 has been linked to a black hole — the first such object to be identified. Though invisible to the unaided eye, the massive, blue giant star in the system can be seen through a large telescope. However, its real significance was unknown until its X-ray emissions were studied and theoreticians developed the concept shown on page 4.

Thorne says it's almost certain that only the inner regions collapse. As the outer regions try to collapse they heat up (whenever a gas is compressed, it heats up), and there is a sudden nuclear explosion that ignites the remaining fuel in the outer parts and blows them off. So in reality if we try to observe the collapse from the outside we can't — it is hidden from our eyes by the exploding outer regions of the star.

But there may be another way of "seeing" black hole formation. "We may do it in six or eight years," predicts Thorne. "Not by looking with our eyes through telescopes or cameras, but looking instead at the gravitational radiation that is emitted by the star's collapsing core — gravitational radiation which can fly outward through the outer exploding envelopes with impunity; gravitational radiation that just doesn't care that the outer regions are in the way. It just passes right through and hopefully will soon be detected by gravitational radiation detectors that are under development at several institutions in the United States and elsewhere."

Although Thorne is optimistic about future gravity wave detection, Dr. James Ipser, a specialist in relativistic astrophysics at the University of Chicago, summarized the results of several recent experiments.

"It looks as though a series of observations over the last few years were not detection of gravity waves." Ipser was particularly referring to the experiments of Dr. Joseph Weber who has used 3000 pound precision suspended aluminum cylinders, located 600 miles apart, to try to detect waves of gravitation sweeping in from space. Incredibly, tiny vibrations in the cylinders — vibrations smaller than the diameter of an atomic nucleus — have been measured by Weber and theoretically can be ascribed to impinging gravity waves.

The theory seems to be sound, but as Ipser says, "Nobody else sees what he does and it now looks very bad." Instruments cooled to near absolute zero — thousands of times more sensitive — seem to be needed to do the job.

"But I am convinced gravitational waves must be bathing the universe and we're continually being shaken by them as they pass through

Kitt Peak National Observatory Photograph

us," says Thorne. "But that shaking is so tiny that it amounts to shaking our bodies by a small fraction of the diameter of the nucleus of an atom."

So detection of gravity waves emanating from a black hole seems to be some years in the future. In the meantime theoreticians like Thorne and Ipser have developed elaborate pictures of these bizarre objects.

Cygnus X-1, the black hole that we think is being observed by X-ray astronomers, probably has a circumference of about 100 miles. (Thorne prefers to talk in terms of circumference rather than radius because "to measure a radius you have to go in and you can't came back and report your results, but to measure a circumference you can stay outside".) A 100 mile circumference is perhaps a little larger than the typical black hole that we believe exists in our universe. But giant black holes are possible too. Black holes are one way traps — the more material that goes in, the larger they get. Is enough material available to make really colossal black holes?

"I would say it is very likely that at the centers of some galaxies there are huge black holes that are more like a billion miles in circumference," says Thorne. "If you were to go into a neighborhood of a small (normal) black hole, perhaps 20 miles in circumference, long before you reached the edge of the hole you'd get killed.

"You'd get killed because of the gradient in the gravitational field. This means that if you were headed into the hole feet first, because your feet are nearer the hole at any given moment than your head, they get pulled down harder. Even Newton told us this. Einstein told it to us with greater emphasis in different language. So the nearer your feet are to the hole than your head, the stronger they get pulled. That doesn't make much difference for the surface of Earth — you don't feel the difference in gravity between your head and your feet. But long before you reached the edge of the small hole, that difference would become so enormous that the molecules in your body would give way, and you'd just get stretched from head to foot to the point that you'd die."

A wierd difference exists between small and large black holes according to Thorne. He describes it this way:

"If you have a hole that is 100 million miles in circumference, as we think could be at the center of our own galaxy (there could be one a billion miles in circumference at the centers of some galaxies), you would hardly know you were near it. That is, you could go down through the edge of the hole, and you would still be able to see out. Although you can't send signals out, you can have signals come in to you. So you could still look out and see the rest of the universe out there. Unless you were a pretty sophisticated person and knew precisely the right kinds of measurements to make, you wouldn't know you were down the hole until you met whatever fate awaits you at its center."

Thorne believes these supergiant black holes at the center of galaxies have gravitational attraction of 10 to 100 million times the sun's. "The only reason that you're not torn apart at its surface is that the edge of the hole reaches so far out that you're temporarily saved from the crushing forces."

Gravity waves produced by something being swept into the black hole at the center of our galaxy was what Joseph Weber believed he was "seeing" with his gravity wave detectors. As mentioned earlier it now seems unlikely that this is the case.

Nevertheless Ipser thinks the supersensitive detectors of the future will be able to feel the thump of the collapse of a star as it creates its cosmic tombstone in a supernova explosion. Black holes and pulsars (both supernova remnants) are thought to release vast amounts of gravitational energy during their initial formation. Since supernovas occur about once every 50 years per galaxy the chances of detecting the gravity waves from the collapse would be slim if we waited around for one to be created in the Milky Way. But in a cluster of thousands of galaxies supernovae should be a monthly occurence if the whole cluster could be monitored.

Just such a cluster exists. The Virgo cluster of galaxies has about 2,500 members.

"I'm convinced that with continued effort, requiring the spending of perhaps several hundred thousand dollars per year, it should be possible by 1980 to see these gravitational waves from supernovae in the Virgo Cluster," Thorne commented. "Then we will be in the position of really exploring observationally the details of black hole and pulsar formations in a manner that nothing except gravitational wave astronomy can do. And I would say that will be an era as great and exciting as anything that has happened in astronomy since discovery of the expansion of the universe."

Dozens of galaxies are visible in this region of the constellation Coma Berenices. Clusters of galaxies such as this seem to be common. By observing them with special gravity wave detectors astronomers hope to detect the formation of black holes and pulsars — the end products of supernovae explosions. A supernova erupts every few weeks in large galaxy clusters and the event is one that theoretically can be observed. But the detecting devices developed so far are not sensitive enough to "see" them.

What Happened to Comet Kohoutek ?

It was supposed to be the comet of the century — a blazing spectacle in the January evening sky with an 80 million mile tail reaching a third of the way from horizon to zenith. Kohoutek's dazzling head was to be seen rivaling the planet Venus in brilliance. According to the predictions we were in for an awe-inspiring extravaganza from the depths of space.

That's what it was supposed to be. Comet Kohoutek, discovered in March 1973 when it was out near the orbit of the planet Jupiter, was hurtling toward a rendezvous with the sun — a rendezvous that was to melt and spew its boiling gases into a vaporous celestial phenomenon worth viewing by every citizen of planet Earth. But this once in a lifetime view never came true. Kohoutek fizzled. Why? What happened?

Instead of getting rapidly brighter as it approached the sun, Kohoutek mysteriously lagged farther behind its brightness predictions. In November it was more than a magnitude below predictions. In early December it was over two magnitudes behind. In late December as it closed in on the sun it still didn't seem to be doing what it was supposed to — the tail wasn't as long as other comets that have been in similar circumstances. The dust that was going to provide the spectacular tail didn't seem to be there. Observations in September and October revealed some dust but it curiously dried up.

But hopes remained high as Kohoutek rounded the sun on Dec. 28. The heat from our star raised the surface of the comet to over 2000 degrees, enough to boil off its outer layers sending out the hoped-for magnificent streaming tail.

On the first evenings of January thousands peered into the west after sunset to catch a glimpse of the newly revitalized Kohoutek. Now after a blistering hairpin turn around the sun, it was going to blaze into glory. But where was it? Eyes strained; binoculars were reluctantly raised to bring the comet into view. Surely a little optical aid would show it. But no, most observers saw nothing.

The days passed, and still nothing; then reports drifted in. Some observers had caught it barely visible in the dwindling glow about 45 minutes after sundown. Third magnitude some reported; others thought it was fourth. Unbelievable! How could it be so faint? The Skylab astronauts reported that it was about zero magnitude on Dec. 29 (just after it passed the sun). Then it rapidly fell to about third magnitude by Jan. 2, the first day that it was visible to earthbound observers.

The comet's disappointing performance was news for a day or two as the message flashed around the world that Kohoutek was a dud. Quickly it faded from the public eye. But to astronomy enthusiasts and the astronomers who had made the somewhat embarrassing predictions, the failure of Kohoutek was an acute disappointment.

With Kohoutek but a shadow of what was expected it became almost an "overkill" with the batteries of equipment prepared for its scrutiny. The powerful eye of the spectroscope, the coronographs and ultraviolet cameras on Skylab, and high altitude observatories and airborne telescopes — all analyzed the strange object for clues to help determine why it didn't do what other comets had done. One astronomer was so disappointed he didn't bother to use valuable time he had reserved at Mt. Palomar for comet study.

The predictions for Kohoutek were based on the performance of previous well-observed comets that passed at distances from the sun similar to Kohoutek's 13 million miles. But Kohoutek fell

Two tails of Comet Kohoutek are clearly visible in this 19 minute exposure taken Jan. 11 at the Lunar and Planetary Laboratory's Catalina Observatory near Tucson, Ariz., where Steve Larson attached his camera to the side of the 61 inch reflector for guiding. (The orange blob in the lower right corner is part of the telescope.) The camera was equipped with a 135mm lens and Ektachrome EF film. The curving yellowish-white dust tail is the one that is seen visually while the blue gas tail is only recorded in photographs.

Photograph by Stephen Larson

far below the performance of other comets. Indeed, no other well publicized comet fizzled as badly as Kohoutek. As one astronomer remarked, "the comet flap-flopped".

Admittedly some astronomers did realize that Kohoutek was unusual and made significant downward adjustments to the earlier predictions. But it was too late. The stage had been set and the audience had packed the house, but the star performer got sick — very sick.

The structure of comets, which is only roughly known, is certainly at the core of the problem. We just don't know enough about the differences from one comet to another.

Dr. Fred L. Whipple, the world's leading authority on comets, has proposed what is now the generally accepted theory of comet structure. He describes it as a ball of ice or snow with embedded solid particles. The ice need not be water ice alone but can include methane, ammonia, carbon monoxide and other complex ices that become vaporized near the sun producing the comet activity. If this ball of dirty ice is a mile or more in diameter, it can withstand many close approaches to the sun before its substance vaporizes away. Small earthy dust particles, some of them stuck together in larger aggregates, can account for dust tails seen in bright comets.

As sunlight vaporizes or sublimates the ices to gas, the escaping gas carries off the dust particles to produce the general activity of the comet. So the tail of a comet, the thing that makes it the spectacle that it sometimes is, consists of gases — the vapors of the solid ice portion of the comet — and the dust that was embedded in that ice. The dust tail is the one that reflects sunlight and is easily visible to the unaided eye; the gas tail is bluish and not as easily distinguished. The more dust a comet contains the bigger spectacle it will be.

The closer a comet comes to the sun, the more gases vaporize, the longer the tail will be and the brighter the comet will appear. The bigger the comet is, the brighter it should appear. The average comet is thought to be about one mile in diameter. Kohoutek is believed to be a 15 mile wide sphere containing much more material than the average comet. Therefore much more material would be expected to be boiled off as it passed through its hairpin turn around the sun before heading out into space again.

So Kohoutek seemed to have everything going for it. It was big, it was going to pass fairly close to the sun and, initially at least, it was thought that it contained enough dust to make its tail long and bright. If, in fact, the comet did have lots of dust it didn't get released into space: the tail turned out to be only one percent as dense and 10 percent as long as predicted. It certainly passed close enough to the sun to be a great spectacle if it was made the same way most comets are with a mixture of ice and dust. So the big question is, how does Kohoutek differ from other comets? Several theories have been advanced.

Perhaps the most promising speculation comes from Whipple. He suggests that the comet may be layered. It's Kohoutek's first trip around the sun according to the calculations that have now been very precisely determined. So the comet has had a history of at least four billion years in the frigid depths of space. This means that we are looking at its original composition unblemished by a previous trip near the sun. When the comet was formed out of the primordial nebula from which all stars and comets form, its final layer was a blanket of snowy volatile material making the outer layer substantially different from the core.

Observations of the comet made near the time of its discovery showed Kohoutek to be much brighter than practically any other comet in history at a similar distance. So from this, astronomers concluded that it was going to be exceedingly bright when it was near the sun. That assumption seems to have been the big mistake. But how could anyone know? As Dr. Brian Marsden of the Smithsonian Astrophysical Observatory points out, "Comet Arend-Roland in 1957 was nearly as bright, at a distance almost as great as Kohoutek and it followed the predictions beautifully".

According to Dr. A. H. Delsemme, director of the physical study of comets division of the International Astronomical Union, the comet did indeed follow the theoretical brightness pattern of a "new" comet. He says its brightness out around Jupiter was due to the vaporization of the highly volatile material that Whipple suggests. "Once that was gone the inner part of the comet gave up its volatiles much more reluctantly because of its plathrate hydrate structure," said Delsemme.

(A plathrate hydrate is a peculiar molecular crystalization of water with methane and other simple compounds that makes it not as easily vaporized as simple ices.)

The comet would have been 21st magnitude

The wispy gas tail of Comet Kohoutek twines away from the dazzling head in this three minute exposure taken with the 48 inch Mt. Palomar Schmidt telescope on Jan. 12. All photographs illustrating this article show far more detail than can ever be seen visually in binoculars or telescopes.
Hale Observatories Photograph

Artwork by Victor Costanzo

On Jan. 7 Comet Kohoutek was in the same binocular field as Venus. Victor Costanzo observing from Rochester, N.Y., in "murky" skies, saw a one degree tail on the third magnitude comet. Its starlike nucleus contrasted with the brilliant crescent of Venus.

out around Jupiter's orbit if it were not a new comet according to Delsemme. "Then the predictions would have been close to the real values," he said.

Very little is known about the appearance of comets at such great distances — especially new comets on their first trip toward the sun. (New comets account for about five percent of all visible comets.)

So the solution seems to be in Whipple's suggestion that highly volatile compounds in the comet's outer skin were vaporized at great distances from the sun. Then as it approached, these easily eliminated compounds were boiled off into space and ultimately consumed. Below, a layer of less easily vaporized material — either plain water ice or Delsemme's icy plathrate hydrate structure — would be less likely to form a great tail and release the dust embedded in it. Whipple stresses that this is speculation and that analysis over the next few months will show whether the structure that he theorizes is correct.

Another chapter has been added by a team of radio astronomers at Kitt Peak Observatory in Tucson, Ariz. While the comet was far out from the sun, they detected methyl cyanide in its tail and coma. If this compound is not detected and analyzed as the comet recedes from the sun, it would tend to support the idea that there was an outer skin on Kohoutek that was quickly vaporized and the less easily vaporized interior structure produced the fizzled version of Kohoutek that we saw in January. Since this layered structure accounts for what was observed by both optical and radio methods it is gaining popularity.

A comet laden with dust that prevented the underlying ices from being vaporized is pictured by other theorists. But Whipple points out that dust absorbs heat better than ice and that eventually the dust would not be insulating the ices from the sun but would tend to speed the melting process.

Another theory contradicts the comet concept that Whipple has proposed. It suggests that some comets are not balls of ices with dust embedded in them but are instead flying gravel banks — a pile of cosmic debris, rocks and chunks sort of clumped together with much less volatile material than in the Whipple model. Such theories, although not generally in favor right now, still cannot be rejected and may possibly explain the observations of Kohoutek's unusual activity.

An ingenious theory, different again from the others, has been suggested by Dr. Thornton Page, a research astrophysicist at Naval Research Laboratories. He wonders how a comet can get layered if it formed (as most astronomers believe) from a random collection of material at the outer fringes of the solar system. According to Page the comet may have an unusual composition that allowed a

Denver Museum of Natural History Photograph

From a backyard in suburban Denver several staff members of the Gates Planetarium observed and photographed the third magnitude comet near Venus at 6:10 p.m. MST on Jan. 4. A 300mm telephoto lens and High Speed Ektachrome film combined to make this 15 second guided portrait of Kohoutek.

Denver Museum of Natural History Photograph

High atop Colorado's 11,500 foot Squaw mountain, Mark Peterson and Dave Baysinger photographed Kohoutek on Jan. 3 at 6:00 p.m. MST in zero degree weather with 40 m.p.h. winds. Their SLR camera with 55mm lens was set wide open for 15 seconds with High Speed Ektachrome film. Most observers thought the comet was second magnitude at this time, but it was so close to the horizon that few saw it.

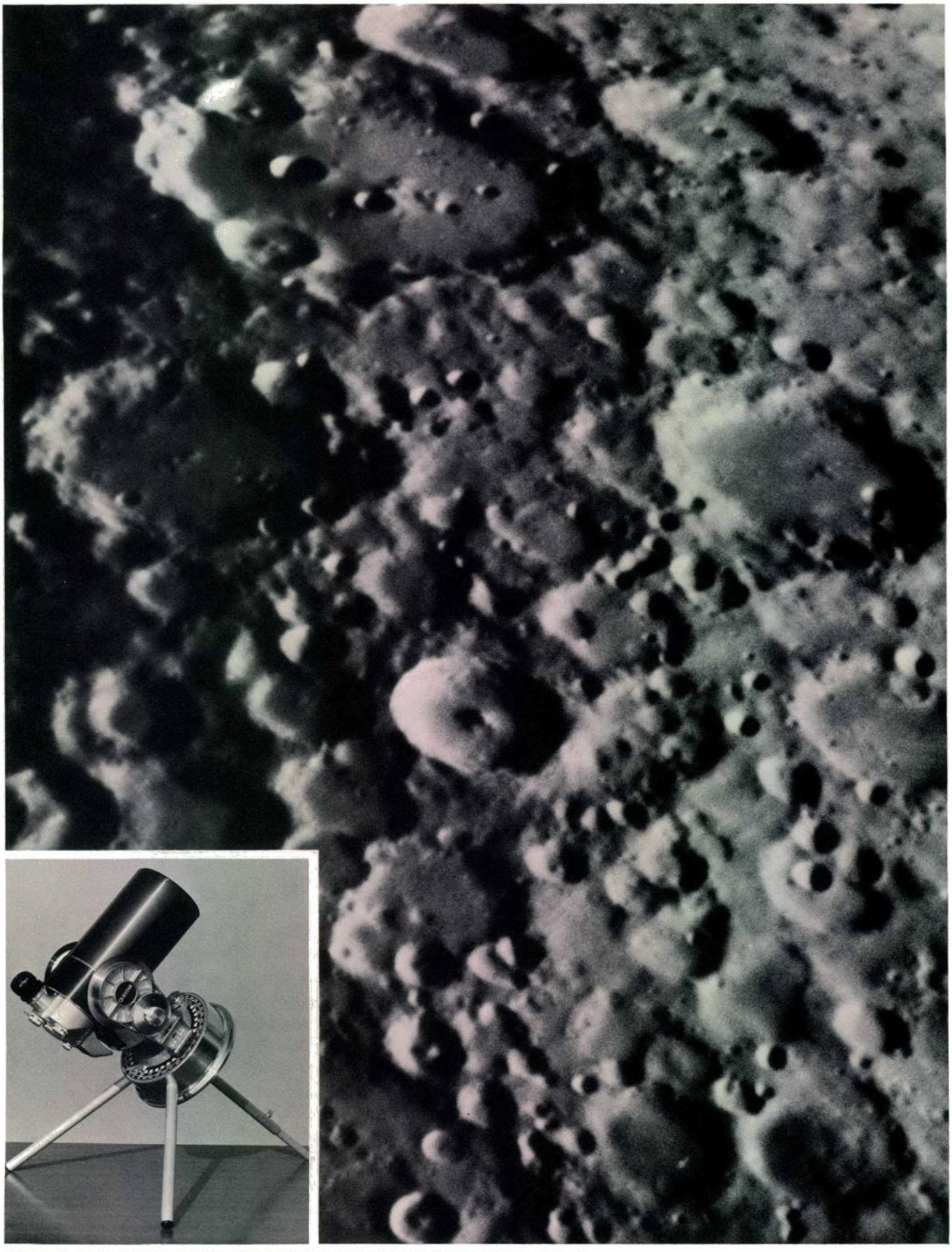
compound to form like a blanket over the nucleus preventing the gases below from escaping.

"There must be a compound that is white, sticky and opaque that could be formed from the right combination of hydrogen, oxygen, carbon, nitrogen and silicon — all plentiful in comets," said Page. He visualized its formation under 2000 degree temperatures during closest approach to the sun.

Perhaps the comet is not part of the solar system at all. Most comets are thought to originate in a comet cloud which surrounds the sun at distances of up to two trillion miles. Comet Kohoutek may be a rare and unusual interstellar voyager — a frozen lump of material from somewhere else in the galaxy that has stumbled across our solar system and become locked in the gravitational whirlpool that surrounds the sun. Some 10 million years ago it came plunging toward our star, an emissary from the true depths of space. During its interstellar travels it could have picked up the volatile compounds that vaporized so early in its approach to the sun.

Perhaps this final suggestion is too far out. Comet Kohoutek did not flop as badly as some other comets in history. Comets Ensor in 1906 and Westphal in 1913 both came streaking toward the sun and flared up with impressive bursts of activity. They were predicted to be magnificent objects as they passed the tail-producing heat from the sun. But despite desperate searches, both comets were never seen to emerge from their close encounters with the sun. Other comets have split in two. This splitting of comets is one of the biggest headaches of cometary theory. It doesn't seem to fit in anywhere and yet it has happened.

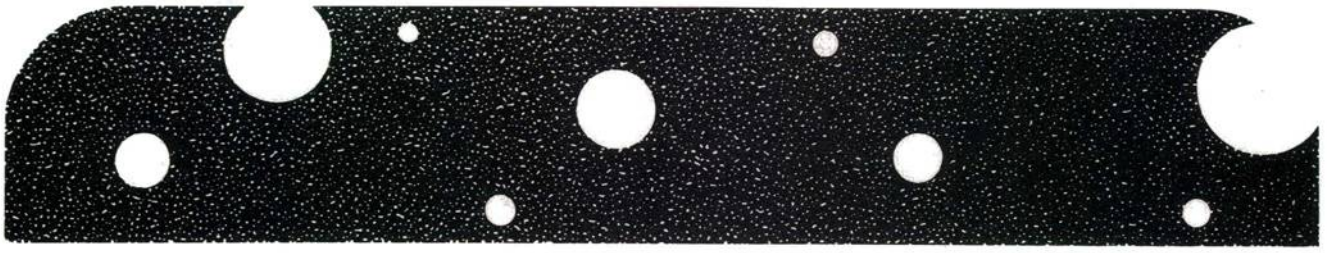
Comet Kohoutek has demonstrated how little we really know about the precise nature of these visitors from deep space. But this comet may be ultimately remembered not as the "comet of the century" but as the "comet that explained comets".



QUESTAR, THE WORLD'S FINEST, MOST VERSATILE TELESCOPE, PRICED FROM $865, IS DESCRIBED IN OUR BOOKLET WHICH INCLUDES THE PICTURE OF CLAVIUS, SHOWN ABOVE, ONE OF 150 PHOTOGRAPHS TAKEN BY QUESTAR OWNERS WITH THE 3½ AND SEVEN. SEND $1 TO COVER MAILING COSTS ON THIS CONTINENT; BY AIR TO SOUTH AMERICA, $2.50; EUROPE AND NORTH AFRICA, $3; ELSEWHERE, $3.50. EXTENDED PAYMENTS AVAILABLE.

QUESTAR

BOX 80, NEW HOPE, PENNSYLVANIA 18938



Magnetic Fields Beyond Earth

by

Gerrit L. Verschuur

We all know what a magnetic field is — that strange invisible force that causes a compass needle to point north and attracts two lumps of iron to one another even though they aren't touching.

Earth has a magnetic field. Without it compasses wouldn't be of much use. Earth's field has changed its direction during the history of our planet and these changes are permanently recorded in the magnetization of rocks deep below the surface. The strength of magnetic fields is measured in units of Gauss, named after the physicist who significantly increased man's understanding of this strange, invisible force. Earth's magnetic field has a strength of about 1/10 of a Gauss at the surface of our planet.

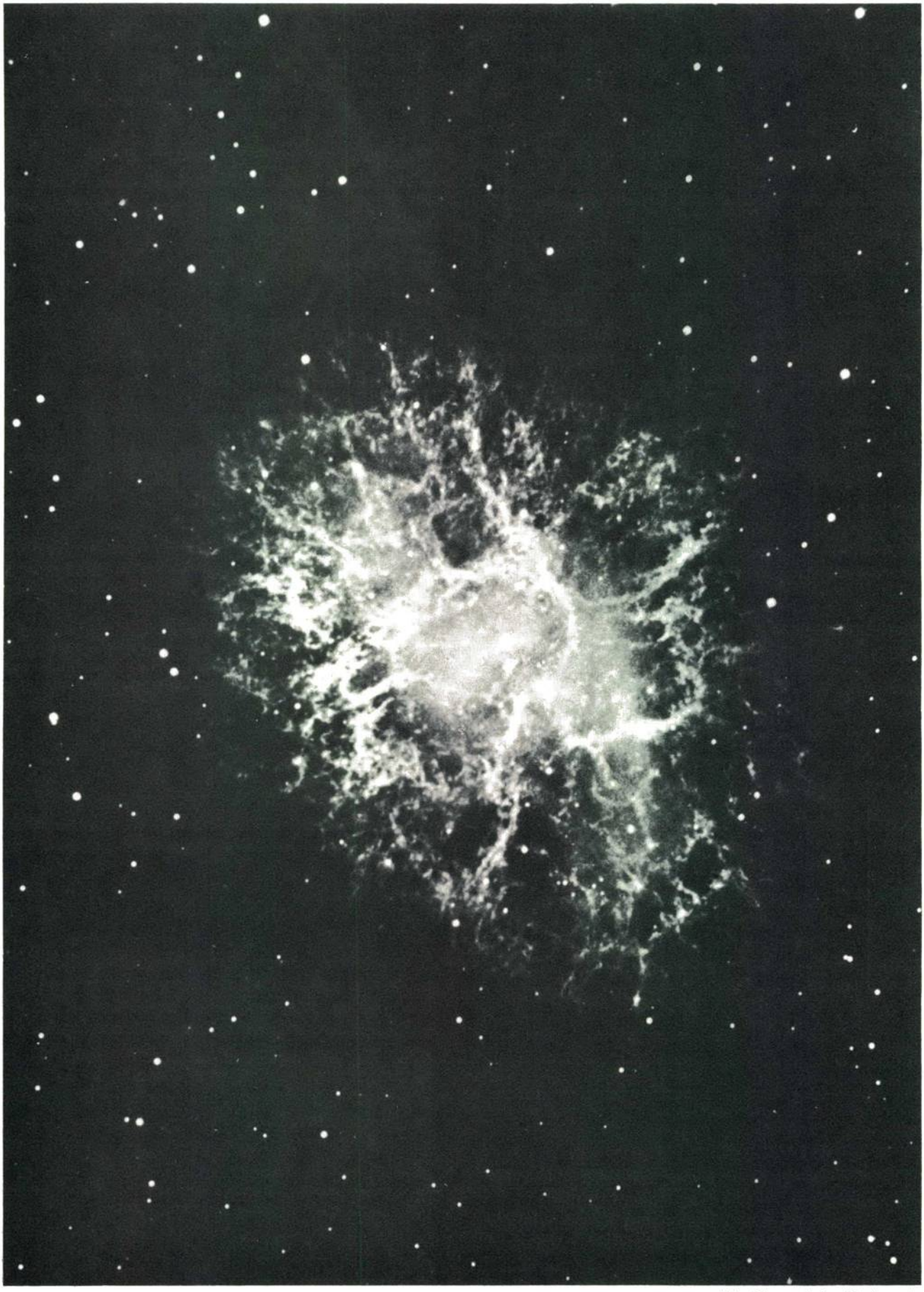
The sun, too, has a magnetic field. So does Jupiter and probably the other planets. The moon has an extremely weak field. On the sun the field strength is about one Gauss, but around sunspots magnetic fields have strengths of hundreds of Gauss. These strong fields determine the motions of hot gases in the solar atmosphere, and the gases contain electrons that are affected by magnetic fields; moving electrons can generate their own magnetic fields. So it is in the sun.

The beautiful loops and curves in solar prominences are usually produced by the structures in the magnetic fields above sunspots. The hot clouds of gases, mostly electrons, are forced to stream along the so-called lines of the magnetic field. They rush upward, and when their energy is expended they fall back down to the surface of the sun, again following the magnetic field lines. Astronomers can learn a lot about the solar magnetic fields in and around sunspots, and daily maps of the solar magnetic fields are produced at several observatories.

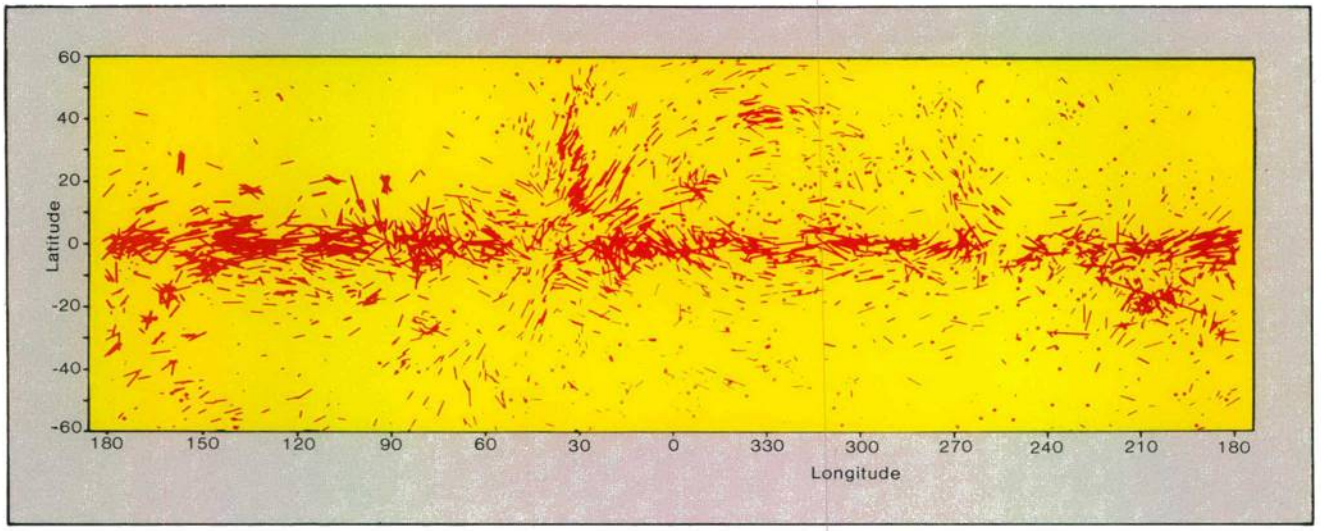
But do magnetic fields exist in space beyond Earth and the sun? Surprisingly they are everywhere. They thread through space between the stars; they permeate dust clouds, forcing some of them to take on an elongated appearance, and they build up in strength as interstellar clouds get denser during their evolution into stars. However, at some point this increase in magnetic field strength should prevent the cloud from condensing any further. This is because magnetic forces tend to counteract the effects of gravity. Yet stars have formed, so for some reason that is not yet explained, magnetic fields must escape the protostellar cloud before the star can be born. Of course there are so-called magnetic stars which have fields of thousands of Gauss, but they too must have lost some of the original fields that would have built up during the early phases of contraction in the gas clouds.

How do we know that magnetic fields exist out there in interstellar space? Obviously we haven't sent a compass into regions of space many light-years from Earth, so how can an astronomer become aware of the existence of something so insubstantial as a distant magnetic field? The answer lies in being able to detect the effects that invisible magnetic fields have on other phenomena or radiations.

As with so many astronomical discoveries, detection of the first interstellar magnetic fields



Hale Observatories Photograph



The Milky Way galaxy is laced with clouds of tiny dust grains that act as field lines on a celestial magnetic map. The dust grains are elongated and tend to line up following the orientation of galactic magnetic field lines. Astronomers, mapping polarization of starlight have produced this map. Each line represents the orientation of the galaxy's magnetic field in that particular direction. The main concentration is along the plane of the galaxy.

was an accident. The discovery arose out of an experiment to search for polarization of light from certain stars which are members of binary systems. First, a word about polarization, a concept that is often difficult to envisage.

We are all familiar with the action of polarized sunglasses that cut the glare on a sunny day. Rotate such a pair of glasses and varying amounts of light appear to be transmitted through to your eye. Set up two pairs of polarized glasses in front of one another, rotate one by 90 degrees, and no light will be transmitted at all. This is because the lenses are actually polarizers. The first pair only allows light vibrating in a certain direction to pass. The next pair would do the same except that if it is rotated by 90 degrees it will only allow light polarized in the new direction to pass. But the first filter already cut that light out, so nothing is left. The point of using polarized sun glasses is that light from the sun, originally unpolarized, becomes polarized on reflection from certain surfaces on the ground. The polaroid filters are therefore lined up so they cut out the reflected light (glare).

Now, if you were to construct a high quality polarizing filter and place it in front of your eyes, looking at the stars and then rotating the filter, you would discover that the brightness of the light from many stars would vary with the angle of the filter. This experiment is not practical since the eye is not sufficiently sensitive to the small amounts of polarization present in starlight, but such filters mounted on telescopes do allow astronomers to measure the polarization of starlight.

The Crab nebula is the contorted remnant of a supernova explosion that occurred in 1054 A.D. The shape of this expanding cloud of cosmic debris is defined by intense magnetic fields.

The first experiments to search for polarization of starlight were motivated by a desire to find out if processes in the atmosphere of certain stars produced polarization at the rims of the stars. This polarization was supposed to follow the curvature of the circle defining the star's surface. It was thought that eclipsing binary stars would be the best candidates but instead it appeared that single stars showed polarization, with different stars showing different amounts of polarization. The experimenters soon found that the amount of polarization correlated with how much dust lay between the star and Earth. Clearly, interstellar dust was affecting the light being received.

Today we know that this is not unreasonable since we know that sunlight, reflected off the ground, becomes polarized. Similarly, starlight being reflected off interstellar dust grains can become polarized. However in this case we don't see the reflected starlight, but that part of the light that makes it through to us (the transmitted light); it too is polarized.

This explanation for the cause of the polarization of starlight led to a better idea of the make-up of the dust in space. For this process to occur we need elongated dust grains which are preferentially lined up by some mechanism. For this, a magnetic field is required, although some suggest that "winds" in space would line up such particles as well. If the magnetic fields do line up the dust

Hale Observatories Photograph

particles and we measure the polarization of many stars, we should be able to make a map of the magnetic field in interstellar space. This has been done. A map of the polarization directions for thousands of stars is shown on page 21. Each little line represents the direction of polarization and hence the magnetic field orientation in the dust clouds in the direction of the stars being measured.

What about the strength of the fields required to align dust particles? No one is certain, and it depends on what the true nature of the dust grains is; but fields around one hundred-thousandth of a Gauss should be enough.

Another way to measure magnetic fields in space involves examining the effect that a magnetic field has on radio signals from clouds of hydrogen gas. The experiments are difficult and so far only five measurements have been successfully made. They show fields of only several millionths of a Gauss in some clouds. That is a very weak field and exists in clouds many thousands of light-years from us; yet we can measure it.

Another direct indication of the presence of magnetic fields in space comes from observations of radio signals from the Milky Way. Interstellar space is full of cosmic rays — high energy electrons travelling nearly at the speed of light. When these cosmic rays find magnetic fields, they are forced into giant spirals around the magnetic lines of force. In so doing they lose energy by radiating it away as radio signals. This generates the radio static that Karl Jansky, back in the 1930 s, discovered coming from the Milky Way.

Radio astronomers map the radio emission which comes from all along the Milky Way band and find that the radio signals are polarized. Radio astronomers measure the polarization of radio waves by rotating their antennas while pointing at the source. You can do such an experiment with your TV or FM antenna. If you rotate the antenna from the horizontal to the vertical position, while still pointing at the distant transmitter, you will find the received signal weakens considerably. This is because the transmitter is sending out a horizontally polarized signal and your antenna is polarized along the direction of its maximum length. You have to place it horizontally to pick up most of the signal.

Supernova remnants also contain strong magnetic fields. As the shell of matter from the explosion expands away from the exploded star, magnetic fields in space around the original star build up so that the shell actually acts as an amplifier of the surrounding magnetic fields. In addition the explosion generates a large number of high energy particles — we would call them cosmic rays — and these rush outward and meet the surrounding regions of compressed magnetic fields. The result is that radio signals and light are emitted by the cosmic ray particles as they spiral about the field lines. Hence, we can see such objects as the Crab nebula and also pick up radio waves from it.

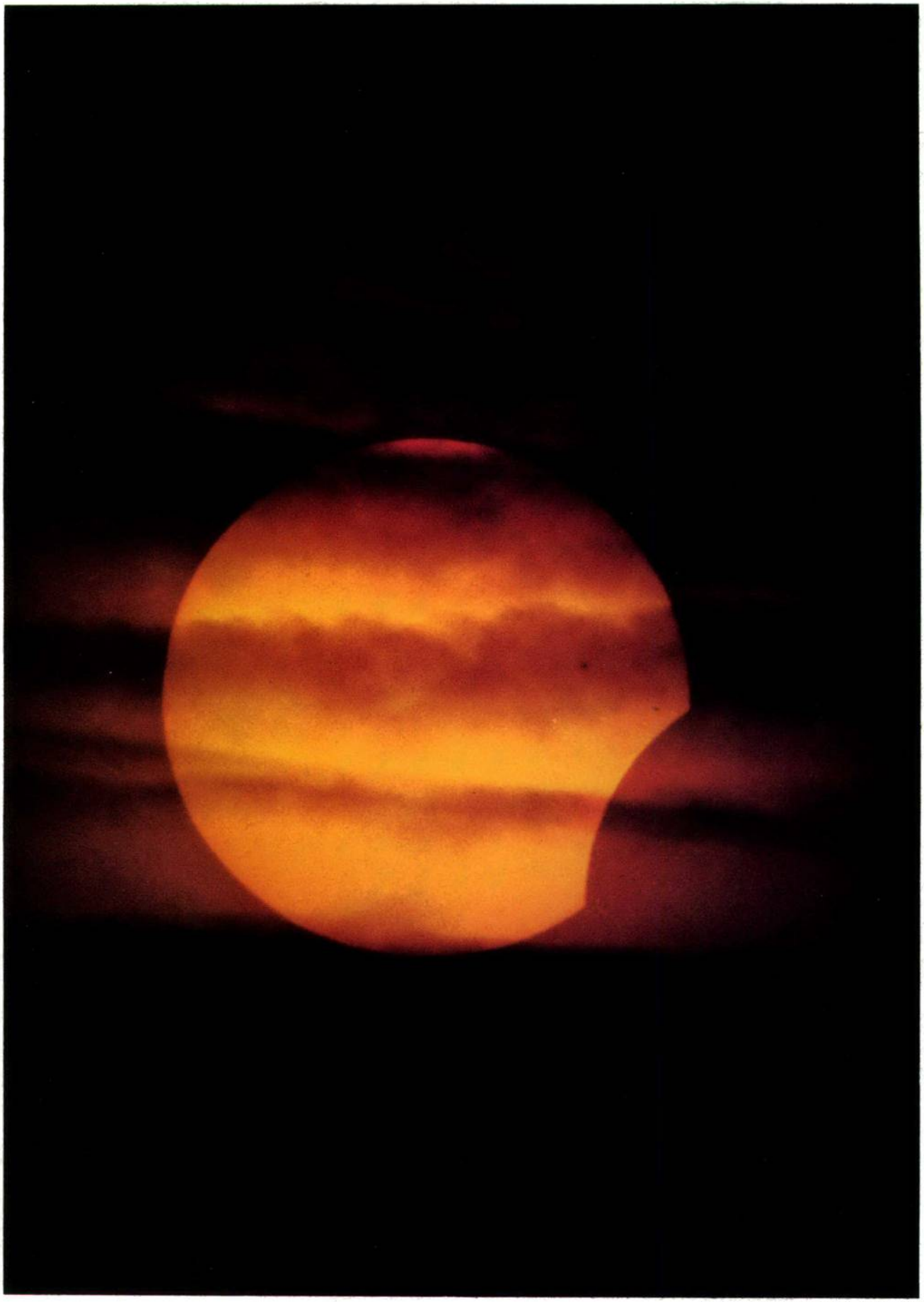
The light from the nebula is also polarized and photographs taken with the polarizing filters at different angles reveal this polarization quite clearly. In the case of this emission, the direction of the polarization of the light is at right angles to the field lines. Examination of the photograph of the Crab nebula on page 22 shows elongated structures at right angles to the angle of the filter, because it is the emission from cosmic rays spiraling about those particular magnetic field lines which we see. The magnetic fields in the filaments of the Crab nebula are about one-thousandth of a Gauss in strength.

Radio signals from distant radio galaxies and quasars are also polarized and magnetic fields in those objects are at most a few ten-thousandths of a Gauss. But none of these objects is a record holder as far as strong magnetic fields in astronomy are concerned. That distinction is held by pulsars.

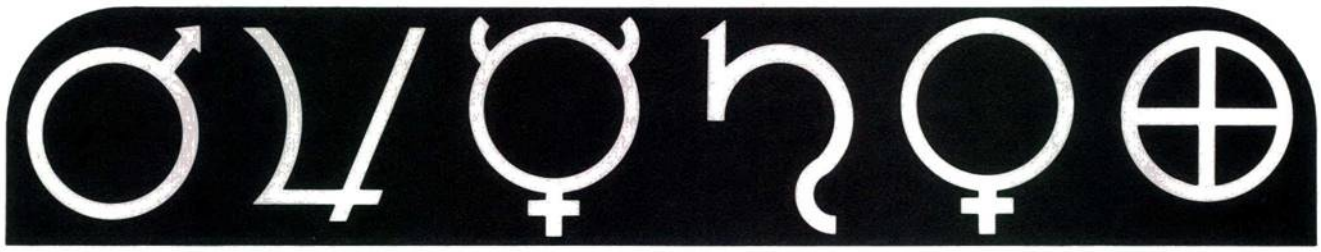
In order to explain the incredibly regular pulses of light, radio or X-ray emission from pulsars, astronomers have had to invoke a complicated picture of what a pulsar is. Basically it is an incredibly dense 10 mile wide sphere called a neutron star. As it rotates, usually several times per second, it carries an intense magnetic field around with it.

In addition we have to have something asymmetrical occurring so that we only get one pulse per rotation. The way to do this is to put the magnetic field in the spinning star with its poles offset from the axis of rotation, just the way Earth's magnetic north pole is not at the true north pole. If this situation exists in the pulsar, then we should regularly see each magnetic pole of the pulsar facing us once per revolution. This has allowed an estimate of the magnetic field strength of pulsars to be made. The answer comes out to a staggering one trillion Gauss. This means that astronomers are observing cosmical magnetic fields ranging from one-millionth to one trillion Gauss. There are probably few other single physical parameters being studied today which show such an enormous range of values.

The magnetic fields of the Crab nebula cause electrons to spiral along the lines of force resulting in emission of polarized light. Photographs taken at different polarization angles (arrows) show that visible light has been polarized at various angles. If it were not polarized the nebula would appear the same in each photograph. This is, therefore, photographic evidence of magnetic fields in space.



Photograph by Frank B. Zoltowski



Spring Begins in Planet-Poor March Sky

On Mar. 20 at 8 p.m. EDT spring begins for the northern hemisphere — the point when the sun is exactly over the equator, and days and nights are of equal length over the entire planet. But for sky observers, the warming trend in the weather automatically means shorter nights, later sunsets and, in this particular month, not very many planets to observe.

A partial eclipse of the sun, visible just after sunrise from the extreme eastern portion of the United States on Dec. 24, 1973 was photographed from Norristown, Pa. Early morning clouds near the horizon added luster to this usually unimpressive event. High Speed Ektachrome film at the prime focus of a filtered six inch reflector was the combination for this 1/125 second exposure.

In the fall of 1973, the sky was dazzling with four brilliant planets visible each evening for about three months. But now our only evening planet is Saturn; it has been with us for several months and is still in good observing position.

Saturn

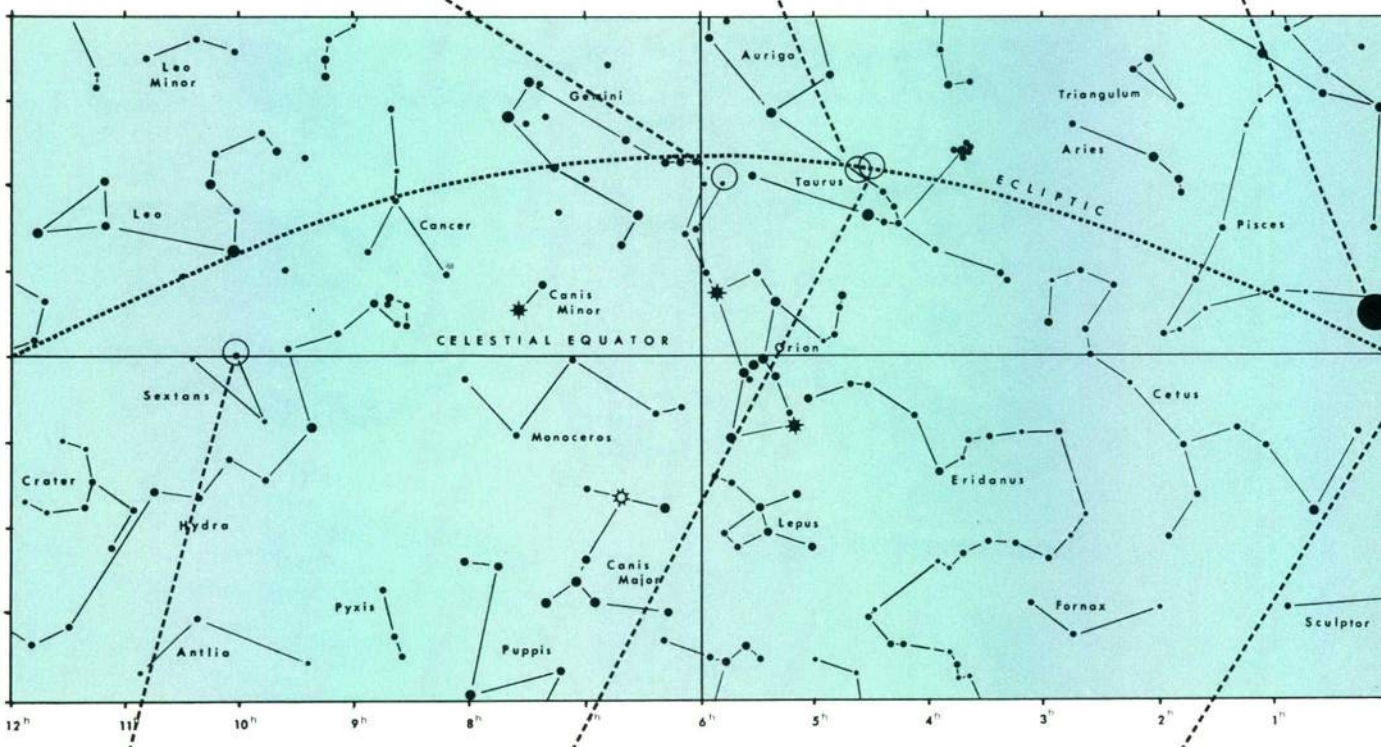
The ringed planet is high in the south at sunset and during the next several hours each evening it moves toward the western horizon by Earth's rotation. This month Saturn is in the uppermost section of the constellation Orion between Taurus and Gemini as shown on the chart on page 34 in

FIRST QUARTER
March 1
R.A. 4h36m
DEC. +23°19'

SATURN

March	1	16
R.A.	5h50m	5h51m
DEC.	+22°33'	+22°36'
DIST.	8.663A.U.	8.908A.U.
DIA.	17.2"	16.7"
MAG.	+0.2	+0.2

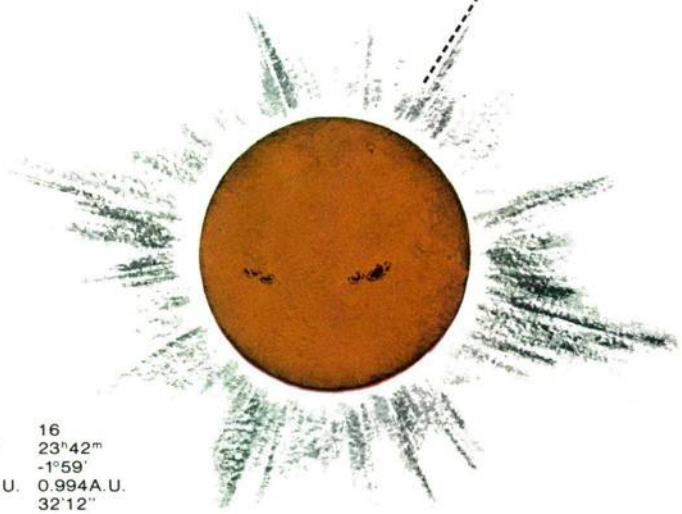
NEW MOON
March 23
R.A. 0h2m
DEC. +5°35'



FULL MOON
March 8
R.A. 10h06m
DEC. +0°24'

MARS

March	1	16
R.A.	3h53m	4h29m
DEC.	+21°53'	+23°25'
DIST.	1.413A.U.	1.560A.U.
DIA.	6.6"	6.0"
MAG.	+1.0	+1.2



SUN

March	1	16
R.A.	22h46m	23h42m
DEC.	-7°49'	-1°59'
DIST.	0.990A.U.	0.994A.U.
DIA.	32'20"	32'12"

Map by Raymond G. Coutchie

JUNO

March	1	16
R.A.	20h 37m	21h0m
DEC.	+10°19'	+8°51'
DIST.	3.643A.U.	3.491A.U.
MAG.	+10.5	+10.5

JUPITER

March	1	16
R.A.	22h03m	22h16m
DEC.	-12°49'	-11°37'
DIST.	5.994A.U.	5.923A.U.
DIA.	30.6"	31"
MAG.	-1.5	-1.6

PLUTO

March	1	16
R.A.	12h49m	12h47m
DEC.	+13°23'	+13°36'
DIST.	30.082A.U.	29.995A.U.
MAG.	+14	+14

THIRD QUARTER

March 15

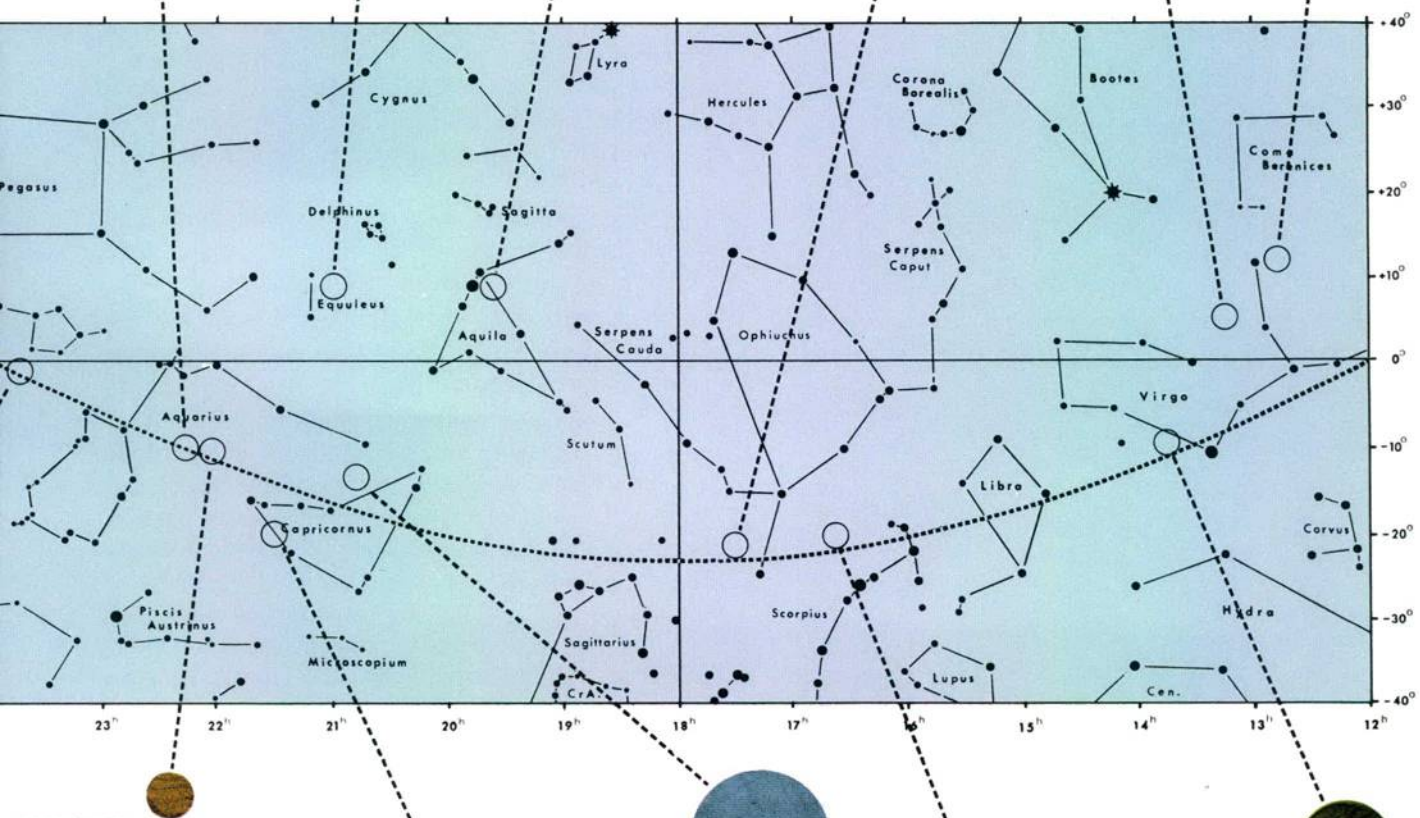
R.A.	17h37m
DEC.	-23°16'

PALLAS

March	1	16
R.A.	19h21m	19h37m
DEC.	+7°09'	+8°50'
DIST.	3.804A.U.	3.677A.U.
MAG.	+9.9	+9.9

VESTA

March	1	16
R.A.	13h18m	13h11m
DEC.	+3°55'	+5°41'
DIST.	1.419A.U.	1.317A.U.
MAG.	+5.9	+5.9



MERCURY

March	1	16
R.A.	22h09m	22h04m
DEC.	-7°45'	-11°43'
DIST.	0.632A.U.	0.791A.U.
DIA.	10.5"	8.44"
MAG.	+1.7	+0.7

VENUS

March	1	16
R.A.	20h05m	20h47m
DEC.	-14°41'	-14°16'
DIST.	0.424A.U.	0.533A.U.
DIA.	39.6"	31.5"
MAG.	-4.3	-4.3

URANUS

March	1	16
R.A.	13h43m	13h41m
DEC.	-10°0'	-9°50'
DIST.	17.743A.U.	17.578A.U.
DIA.	3.8"	3.9"
MAG.	+5.7	+5.7

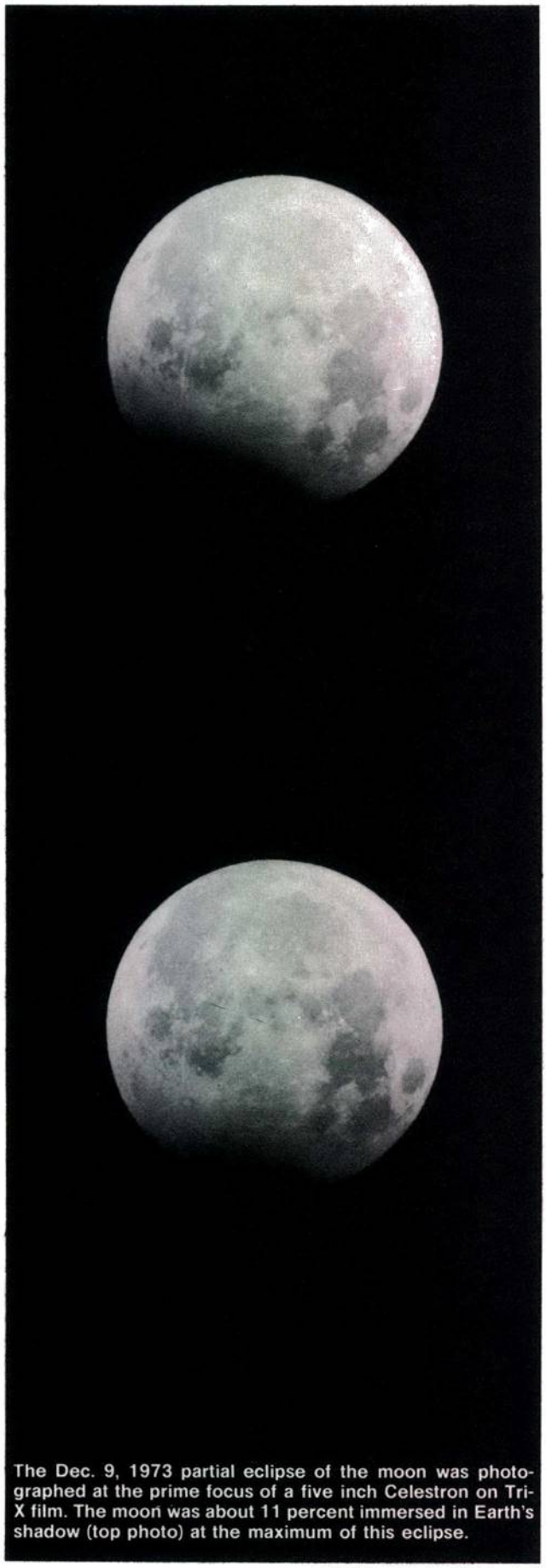
CERES

March	1	16
R.A.	21h06m	21h30m
DEC.	-22°31'	-21°16'
DIST.	3.795A.U.	3.692A.U.
MAG.	+8.5	+8.5

NEPTUNE

March	1	16
R.A.	16h33m	16h33m
DEC.	-20°19'	-20°19'
DIST.	30.283A.U.	30.027A.U.
DIA.	2.4"	2.4"
MAG.	+7.7	+7.7

This planet finder chart shows the positions of the sun, moon, planets and brighter asteroids for the current month as they appear against the background of the zodiac. Positions are plotted for the 16 th with additional ephemerides for the 1st. To find zodiacal constellations visible during the current month, see Star Dome.



The Dec. 9, 1973 partial eclipse of the moon was photographed at the prime focus of a five inch Celestron on Tri-X film. The moon was about 11 percent immersed in Earth's shadow (top photo) at the maximum of this eclipse.

Photographs by Hal Jandorf

this month's Star Dome.

Saturn is still almost as bright as it was last Christmas when it was nearest Earth. Its distance during March increases from 805 to 853 million miles from us and its magnitude decreases very slightly from +0.2 to +0.3. Through a telescope the ball of the planet itself will appear about 18-1/2 seconds of arc in diameter and the rings are, from edge to edge, about 42 seconds across.

On Mar. 2 the first quarter moon will pass in front of the ringed planet. The event is called an occultation, with Saturn being the body occulted by the moon. Unfortunately it's only visible in a small area in North America which includes the Canadian provinces of Quebec, New Brunswick, Newfoundland, Prince Edward Island, most of Nova Scotia and the region around Ottawa. In the United States only the northern half of Maine (north of Bangor) will be in the region where the occultation will be visible. For those who do get a chance to see the occultation, it begins at 6:50 p.m. EDT in the Montreal area and at similar times in the rest of the observing region. Specific times vary from place to place so be out at sunset to watch for the disappearance and the reappearance of the planet as it "passes" behind the moon.

The only other planetary occultation by the moon will be one of Venus in July, more easily seen across North America.

The moon is constantly passing in front of stars as it moves in its orbit but very seldom does it pass in front of bright stars and even less frequently in front of planets. When it does pass in front of a star, the light of the star is extinguished almost instantaneously because the atmosphere of the moon is so tenuous that it cannot be observed visually. Indeed, occultations were one of the early proofs that the moon did not have an atmosphere. The occultation of a planet, however, requires several seconds.

Mars

Mars continues its recession from Earth as the two planets are now at nearly opposite sides of the sun. Mars appears in Taurus as a first magnitude reddish star — magnitude +1.0 at the beginning of the month and +1.4 by the 31st. Its distance during this time increases from 131 million to 159 million miles from Earth and its size is so small (less than seven seconds of arc) that it looks practically like a point of light in small telescopes. Even very large telescopes probably cannot show the surface features of the planet at this time.

Mars passes right through the midst of Taurus during March and provides an interesting visual spectacle from night to night as it moves among the stars of that constellation. At the beginning of

The moon was too far from Earth to completely cover the sun during the eclipse of Dec. 24, 1973. Such a circumstance produces the far less spectacular annular eclipse. The partial phases of this eclipse were visible over a wide range (see pages 24 and 30) but the true annular or ring appearance was seen only in parts of Costa Rica (where these photos were taken), Panama, Colombia and Brazil.

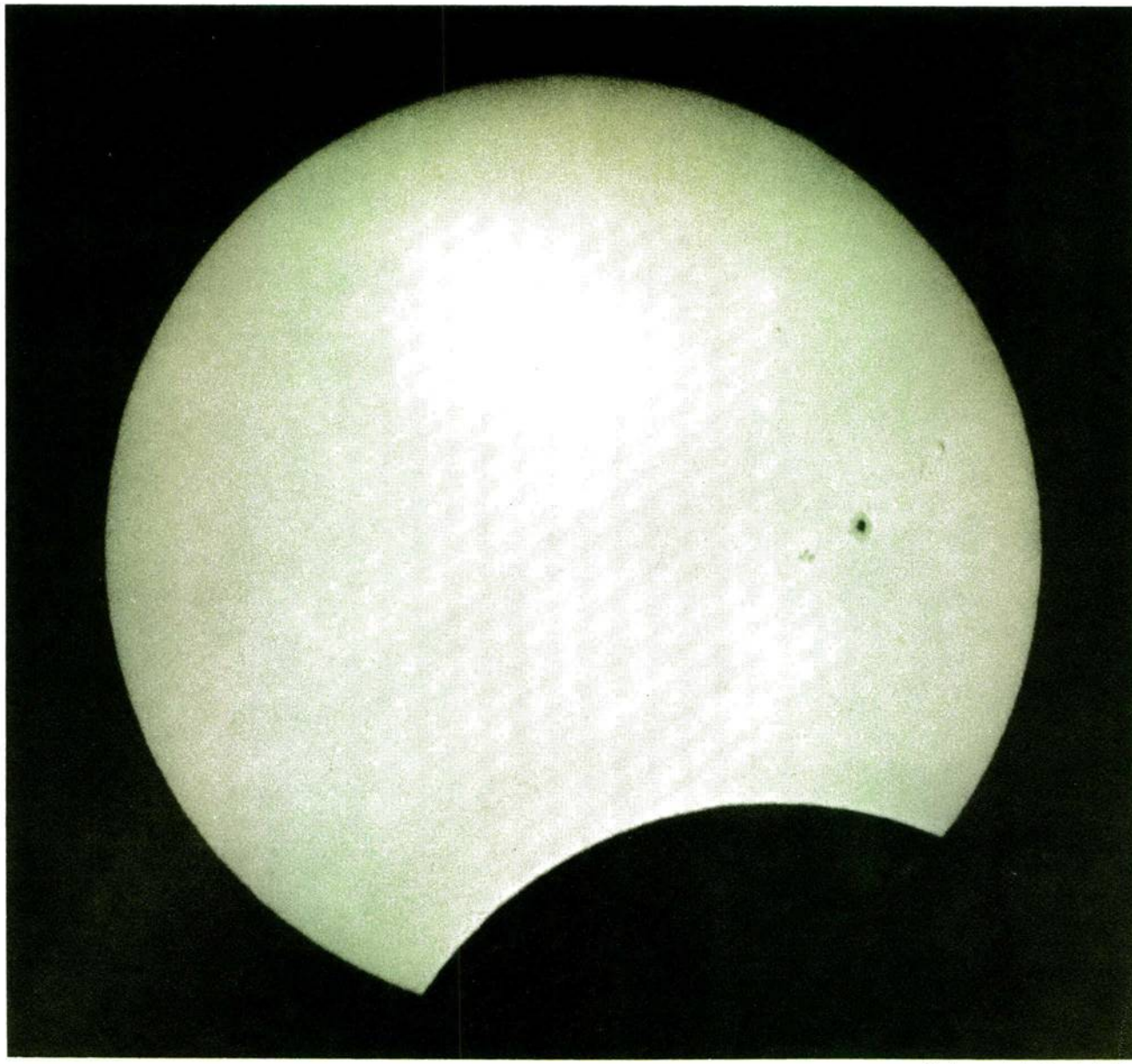
Photographs by John J. Paris

the month we find Mars about four degrees south of the Pleiades. On the 20th it's due north of Aldebaran and about the same magnitude. Note the similarity in color between the star and planet — a similarity that is only superficial. It's also interesting in a situation like this to see how the star twinkles but the planet doesn't. By month's end Mars is heading out of Taurus eventually to pass between Beta and Zeta, the ends of the two horns of Taurus. Taking a look at Star Dome, the planet's path will be basically along the ecliptic as marked on the map and its position at the end of the month is just about on the line from Beta Tauri to Aldebaran.

This is an ideal opportunity for constellation photographers to record the motion of a planet through an interesting star field. ASTRONOMY, of course, welcomes examples of this and other sky photography for use in the magazine.

Venus

Venus is in the morning sky throughout the month, very brilliant and easily visible before sunrise. With daylight time throughout most of the country many people are now getting up in pitch



Photograph by Hank Cutler

From Haddonfield, N.J., the partial solar eclipse of Dec. 24 was photographed at 1/125 second with Plus-X film at the prime focus of an eight inch reflector. The aperture was reduced to 2-1/2 inches to accommodate a solar filter. Filters that eliminate 99.999 percent of the sun's radiation are necessary for both visual and photographic solar study. Unfiltered telescopes are potentially dangerous. Even a quick look can do permanent eye damage.

black conditions in which Venus will be a striking object in the southeastern sky. Its magnitude during the month varies from -4.3 to -4.0 as it increases its distance 39 to 61 million miles from Earth. During that time its diameter decreases from 40 to 25 seconds of arc as its phase increases from 26 percent to a nearly half illuminated 47 percent. Of course the phases of Venus are normally only visible in a telescope but high power binoculars, rigidly held, may reveal the phases early in the month.

Mercury and Jupiter

Both planets are too close to the sun during the entire month for easy observation, being extremely low in the early morning sky. They will be more conveniently positioned later on in the year.

Vesta

On rare occasions a large member of the asteroid community that resides between the orbits of Mars and Jupiter comes close enough to Earth to be easily visible with the help of binoculars. Such is the case with Vesta this month as its distance decreases from 132 to 118 million miles from Earth, which is practically as close as it can get. Tips for observing Vesta, including charts, are in this month's Gazer's Gazette.

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

We've grown since our first issue last August when ASTRONOMY was only 48 pages. Today we are 64 pages big, and just over the horizon is another size increase to 80 pages. The magazine's color and quality have improved, and the new department Astro-News has expanded our ability to bring you the freshest, most up to date information about the world of astronomy. We've inaugurated a completely new department idea — Astro-Mart — where noncommercial subscribers get two free 40 word classified advertisements each year as a special privilege with their subscription. We've provided new color portraits of the planets and universe — photographs that have never appeared in print before.

Isn't it time for you to join a leader — shouldn't you enter your subscription to ASTRONOMY today? Discover the world's most beautiful astronomy magazine for yourself.

1 Year	$12.00
2 Years	$22.00
3 Years	$30.00

Canada and Mexico add $3.00 per year. All other foreign add $6.00 per year.

ASTRONOMY Magazine
Circulation Services
1726 North 1st St.
Milwaukee, WI 53212

MARCH

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

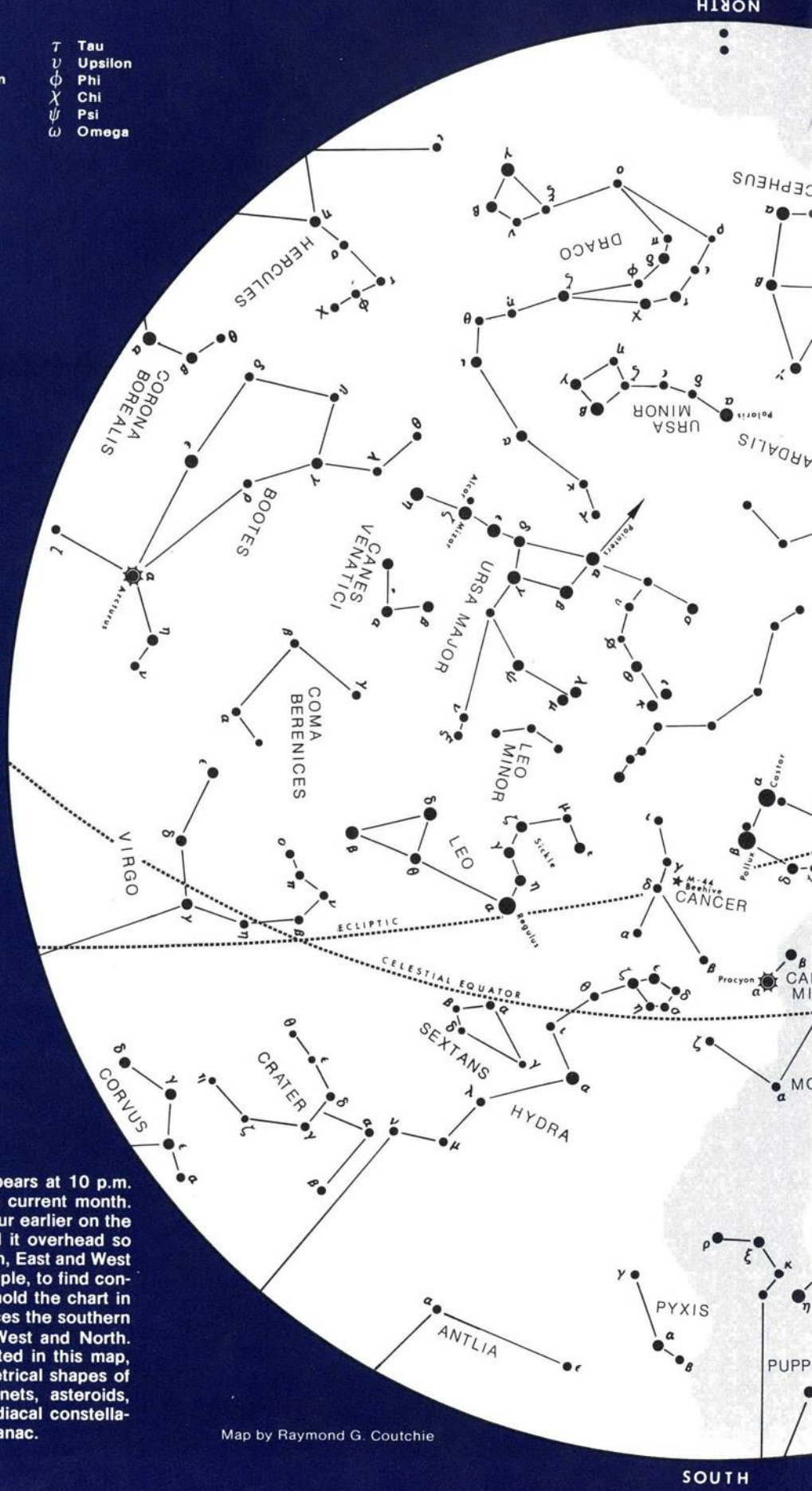
α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars



Map by Raymond G. Coutchie

Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME

Map Centered on 43° North Latitude

The skies of late winter offer a parade of brilliance unmatched by any other season. Orion, high in the southwest, is surrounded by first and second magnitude stars, making it the brightest region visible from the northern hemisphere. With Saturn in the midst of this grouping the pattern of stars and constellations appears slightly distorted but even more brilliant this year.

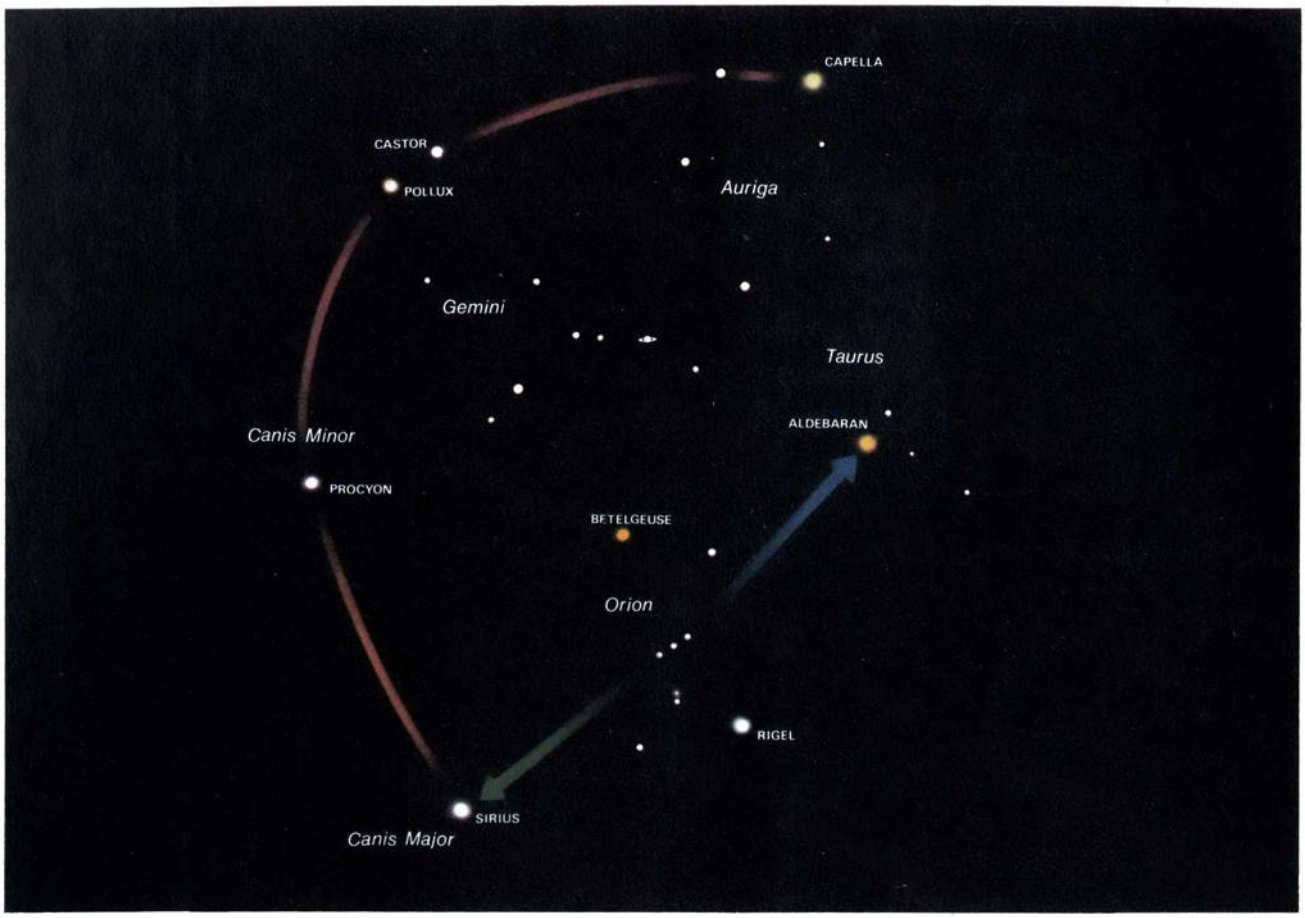
There are some easy ways to learn the late winter stars, and once they are identified by use of some simple curves and lines imagined in the sky, the main features of six constellations can be forever locked in your memory. All constellation finding has to begin somewhere and we'll start with Orion, the most easily identified of any constellation in the sky.

Orion's three bright "belt" stars, and those surrounding marking his shoulders and his legs, form an unmistakable configuration in the winter sky. Nowhere else do as many brilliant stars cluster in such a distinctive pattern. Using Orion's belt as a pointer we can direct it to the left (down) to Sirius, the most brilliant of all the stars in the sky — apart from our sun, of course — and the star that more than any other seems to twinkle and flicker as we look at it.

Usually Sirius appears white or bluish but in conditions of turbulent atmosphere Sirius can seem to run through the whole spectrum of colors, especially if it is fairly low toward the horizon. But in March Sirius is high in the early evening. It is the main object in the constellation Canis Major — one of Orion's hunting dogs. Sirius itself is Greek for "the scorching one", an appropriate name if comparison with all the other stars was intended. Sirius is also the nearest star that can be easily identified with the unaided eye. Its distance is 8.7 light-years or about 51 trillion miles. Beginning with Sirius there is a gentle curve of brilliant stars forming an approximate letter "C" that encompasses the Orion region. The curve sweeps up from Sirius through Procyon, Pollux, Castor and Capella.

Taking each of these stars in turn we first encounter Procyon, brightest star in a small constellation named Canis Minor — the small dog of the two hunting companions of Orion. Procyon is a very brilliant star (magnitude +0.4) and it's only because Sirius is nearby that it is not much more of a landmark star than it has turned out to be. Procyon is a star similar in actual brightness to Sirius but it's a little bit farther away at 11.3 light-years — still a relatively nearby companion to the sun.

Moving up on our identification curve, Pollux is the brightest star in Gemini the Twins, a zodiac constellation. Gemini is peculiar in its star desig-



Artwork by Victor Costanzo

nations. Alpha is normally the brightest star in a constellation, but in Gemini, Alpha is the second brightest and Beta (Pollux) is the brightest. Presumably either Pollux has gotten brighter or Castor fainter since these Greek letter designations were given to the stars about 400 years ago. Pollux is a giant yellow star about 35 times brighter than the sun, 35 light-years away.

Castor, the other bright star in Gemini, is a multiple star system consisting of six suns, four of which are bigger and brighter than ours. The distance of this multiple star system is 45 light-years and the magnitude of their combined light (seen as a single star to the unaided eye) is +1.6.

Our "C" shaped identification curve ends with Capella in the constellation Auriga (pronounced aw-RYE-ga). Capella is very nearly zero magnitude at +0.1. It is the brightest star in this part of the sky and the nearest first magnitude star to the north celestial pole. Capella is 45 light-years distant and the most luminous of the stars that we have so far talked about equalling 160 times the light output of the sun.

Starting back at Orion's belt, we this time point up from the belt and are directed to Aldebaran (pronounced al-DEB-a-ran); at magnitude +0.9, it is the brightest star in the constellation Taurus. In comparison, Betelguese in Orion (although slightly variable) is +0.4 and Rigel is about the same as Capella at +0.1.

For the next couple of years the planet Saturn is going to be in this vicinity to add brilliance but sometimes confusion to the unwary sky gazer. Now, in March, Saturn is in the constellation Orion. Very seldom is a planet ever within the boundaries of Orion. The section of Orion that it's in is a small tip of the constellation that nestles between Taurus and Gemini. It's a part of the constellation that surrounds the end of Orion's club that he, as a hunter, is holding above his head. The position of Saturn is shown on the chart on this page.

So with the help of our arrows and curves, the late winter and early spring grouping of brilliant stars accompanying Orion can be indentified and enjoyed. Once this basic identification takes place the details of each constellation quickly become familiar. And then the more consuming, but satisfying task, of finding the interesting objects within each constellation becomes possible. It is for this reason that Constellation Close-Up, a regular department of this magazine, was established to allow detailed investigation of each constellation. Star Dome will serve to provide background on the constellations and tips on how to identify them. Naturally, we will continue to regularly include mythological anecdotes about the stars and constellations in Star Dome.

LAST CHANCE TO ORDER

THE 1974 ORION CALENDAR

New From ASTRONOMY

1974 has arrived. And to celebrate its arrival we designed a large magnificent calendar wall poster.

This huge, colorful poster, 22 x 34 inches in size, shows a breathtaking blowup view of the Great Nebula in Orion. Photographed by one of the country's leading freelance astrophotographers, Orien A. Ernest, this detailed blowup exhibits all the colorful splendor that exists in astronomy.

Frankly, we feel the photograph rivals the one made with the 200 inch Palomar telescope.

The intense reds and blues — the dark rifts of dust in this beautiful emission nebula will excite and amaze you as you reflect on the fact that new stars are forming there. A billion years from now, as our descendants gaze toward Orion, they may see a beautiful cluster of stars like the Pleiades.

The Orion Calendar would grace any wall, whether bedroom, classroom, study or office. And it would make an excellent gift for anyone — for the casual enthusiast, student or serious amateur.

This lithographed reproduction is printed on heavy, 8 pt. poster board. And the quality is uncompromisingly excellent! To insure that the Orion Calendar reaches you in A-1 condition it will be rolled — NOT FOLDED — and shipped to you in a mailing tube.

Actual Size: 22" x 34"

FOR QUALITY SO EXCELLENT YOU COULD PAY MUCH MORE.

But the cost to you is only $3.50 including shipping. In quantities of 12 or more, only $3.00 each. This fine poster is not available from any other source.

Order your 1974 Orion Calendar today.

ASTRONOMY, 757 N. Broadway,
Suite 204, Milwaukee, Wis., 53202.

ASTRO-MART

FOR SALE — Criterion 6" reflector on Edmund equatorial tripod mount; accessories included. Very good condition. Asking $110.00. Will consider selling parts also. Write George Desmarais, 817 Central Ave., Dover, NH 03820.

FOR SALE — New 6" richest field telescope. Has 6" Coulter primary and 2.14" Coulter secondary. Most parts are Edmund Scientific. Price: $80.00 firm. Contact Dennis Saldusky, 211 W. Jackson, Fostoria, OH 44830. Phone (419) 435-2414.

FOR SALE — Standard Questar with Nikon coupling set and azimuth brake. Excellent condition. Price: $850.00. Contact Bernard Zuckerman, 4 MacLean Dr., Framingham, MA 01701. Phone (617) 877-2357.

FOR SALE — 12-1/2" classical Cassegrain f/14 telescope. Professionally figured null-tested optics. Heavy duty yoke mount with R. A. motorized drive. A. C. and D. C. power systems. Setting circles and 25x guide scope. Price: $2,000 or best offer. Contact John M. Orange, 24 Lincoln, Jeannette, PA 15644. Phone (412) 523-2718.

FOR SALE — 8" reflector in good condition. Includes: f/8 mirror, phenolic tube, equatorial mount, accessories. Will sell complete or for parts. Write Geoffrey Simonds, 112 Fieldstone Rd., Cherry Hill, NJ 08034.

FOR SALE — Set of 5 optical glass University astrofilters (red, yellow, green, 8x neutral density and skylight); will fit all University adapters. Bought in June and hardly used. Price: $12.00. Also 6 Criterion eyepieces: 30mm, 18mm, 12.7mm, 9mm Acromatic Ramsedens, 4mm orthoscopic, Barlow. $10.00 each. Write Marc Bielski, 24 W. 60th St., New York, NY 10023.

ASTRONOMICAL PUBLICATIONS

POSTCARDS CHARTS POSTERS SLIDES

write For Free Catalog and Sample Postcard

HANSEN PLANETARIUM

15 SOUTH STATE STREET
SALT LAKE CITY, UTAH 84111

FOR SALE — Celestron 8 with enhanced and broadband VLR coatings, T-adapter, Canon ring, piggyback mount, 2 oculars and Barlow lens. Mint condition. Best offer over $750. 00. Will include my library of astronomy books free. Contract Richard L. Mangum, 847 W. 500 N., Orem, UT 84057. Phone (801) 224-0009.

FOR SALE — Celestron 5. Accessories include tripod, 2 wedges, counterweights, visual backs for standard and substandard diameter eyepieces, 7 eyepieces and cases, and diagonal prisms. 2 years old, worth $1,000.00. Price: $500.00. Write Grady Newberry, 6426 Manson, Waterford, MI 48095.

FOR SALE — 16" Cassegrain 240" EFL, electric slow motion, R. A. and Dec., secondary mirror ram for electric focusing with readout, Bodine clock drive, hand control. Also 12" Newtonian 98" EFL, electric slow motion RA and Dec, hand controls, Servo clock, setting circles in RA and Dec. Both scopes heavy commercial equipment; many extras, cameras, eyepieces. All in excellent condition. Contact Walter Hiltbrunner, 501 Gral Trevino Dr., S.E., Rio Rancho, NM 87124. Phone (505) 898-6020.

FOR SALE — The following books, all for only $10.00: "Celestial Objects for Common Telescopes" (2 vol.); "Field Book of the Skies"; "Essentials of Astronomy"; "New Handbook of the Heavens"; "Astronomy", and "Palomar". Write to Paul Martineau, P.O. Box 75, Gorham, NH 03581.

Advertise it free in Astro-Mart.

FOR SALE — Government surplus $6,000 K-37 Aerial camera with Aeroektar f/2.5 12" focal length lens. Lens alone advertised for $150. Price only $89.00. Also 6" f/15 Cassegrain, Coulter optics in Novak mounting. Price: $191.00. Write Robert Trail, 9 Berg St., Winsted, CT 06098.

FOR SALE — Lightweight Selsi altazimuth U-type mounting for lightweight 60mm refractors, with slow motion controls. Instructions included. Excellent condition. Best offer. Contact Steve Hutson, 1010 N. State St., Monticello, IL 61856. Phone (217) 762-5311.

FOR SALE — Edmund 3" reflector telescope in excellent condition. Includes 3x finder, 1/2 F. L. eyepiece, Barlow lens (180x with eyepiece), equatorial mount and sturdy tripod. Write John E. Noonan, 207 Ist Ave. E., Cascade, IA 52033.

SHARE YOUR INTEREST IN ASTRONOMY!

Join an organization dedicated to serving its members, and one of the only U.S. non-profit corporations encompassing all areas of astronomy.

All members receive the AARG BULLETIN and the AARG NEWS in addition to other astronomy publications at no extra cost.

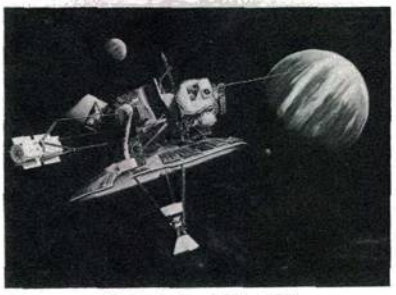
Other benefits include your research and observing results published, eligibility for a planned student scholarship program, and use of AARG's Book Service and Computer Division.

Send 25¢ for complete literature.

American Astronomical Research Group

Dept. 3A
289 Lantana Ave.
Englewood, N.J. 07631
Phone: 201-791-4000

Pioneer 10
Jupiter Mission



(Actual size 17" x 22")

Pioneer 10 gave man his first close-up view of the giant planet Jupiter on Dec. 3, and now a large colorful 17 x 22 inch wall poster commemorates this event. This beautiful lithograph is printed in full color on 7 pt. gloss paper. It will add to the decor of any room and makes an excellent gift for anyone.

This poster (shown in full color in the lead article of ASTRONOMY's *February issue*), *is available in limited* supply ready for framing for $4.00 each. Price includes first class postage and handling, and the poster will *be shipped in a mailing tube.*

Order your Pioneer 10 Jupiter Mission lithograph today.

John W. Clark
3232A North Bartlett Ave.
Milwaukee, WI 53211

FOR SALE — 8" Newtonian with parabolic f/7 mirror, massive fork-type equatorial mount, 12" circles, clock drive, tracking scopes and orthoscopic eyepieces. Excellent condition. Also plans for 8" Newtonian. For more information write David Hughes, 1108 Highland Dr., Kokomo, IN 46901.

FOR SALE — Edmund 4-1/2" equatorial mount with setting circles; good for 3" refractor. Price: $15.00. Also 60mm f/12 Japanese refractor on altazimuth mount with accessories. Price: $15.00, or will take best offer for parts. Write Scott Johnson, 2603 Rogers St., Picayune, MS 39466.

FOR SALE — 10" f/7 Criterion reflector. Accessories include clock drive, slow motion on declination, 7" setting circles, permanent pier, rotating tube, Edmund camera holder, Barlow lens and eyepieces (4mm and 6mm orthoscopic, and zoom 21mm to 8.4mm orthoscopic). Instructions included. Asking $650.00. Write Harold Rossey, 3060 Pageant Rd., S.E., Carrollton, OH 44615.

ANNOUNCEMENT — The 1974 Nat'l. Convention of the Astronomical League will be held at Michigan State University in East Lansing on Aug. 14-18. Amateurs interested in submitting papers should contact program chairman Louis Faix, 6088 Robin Hill Rd., Washington, MI 48094. Discussions on all facets of observing, astrophotography, equipment construction and operation are invited. Oral presentations should be about 20 minutes long. Submit abstracts ASAP; drafts are required by June 15.

Classified ads to ASTRONOMY subscribers. Sell your scope, find an old book, start an astronomy club in your area. Let ASTRONOMY help you — send your 40 word ad to ASTRONOMY, Advertising Dept., 757 N. Broadway, Suite 204, Milwaukee, Wis. 53202.

ANNOUNCEMENT — The Southern Indiana Astronomical Society has recently been formed. Those interested in learning about astronomy and becoming a member, contact Lynn Kaiser, Rt. 2, Box 92, Georgetown, IN 47122. Phone (812) 957-2033.

FREE — Asteroid charts. High quality tracking charts for currently observable asteroids. No obligation. Send long SASE to J. U. Gunter, 1411 N. Mangum St., Durham, NC 27701.

WANTED — Old 6mm Brandon in good condition. Write Dana Patchick, 958 Centinela Ave., Santa Monica, CA 90403.

WANTED — Used 6" reflector in good condition with clock drive. Write to Russ Pavlat, 6622 Elmwood St., Middleton, WI 53562.

ASTRO-MART

FREE CLASSIFIED ADS
to ASTRONOMY subscribers only.

As a noncommercial subscriber you receive two free 40 word classified ads each year as a privilege with your subscription. Commercial advertisers must pay for their ads; rate cards are available on request. Write

ASTRONOMY, Astro-Mart Advertising, 757 N. Broadway, Suite 204, Milwaukee, WI 53202.

BERAL COATINGS

The ideal coating for front-surface precision mirrors for these reasons:

1. **BERAL** has high reflectivity.
2. **BERAL** is hard; does not sleek easily.
3. **BERAL** can be cleaned easily — no porous overcoating of quartz.
4. **BERAL** is not a Chromium alloy, so can be removed easily.

Prices for BERAL coating telescope mirrors: 3", 4¼", and 5"—$6.00; 6"—$8.00; 8"—$10.00; 10"—$12.50; 12½"—$16.00. Prices for sizes up to 37" diameter on request. Diagonal 2" minor axis, or smaller, when sent with mirror—$3.00. Add Postage and Insurance for return mail.

DUDLEY LE ROY CLAUSING
8038 Monticello Ave., Dept. 2A; Skokie, IL 60076

WANTED — Edmund 32mm Erfle eyepiece in good condition for 2" diameter focusing mount. Will pay up to $25.00. Contact Eric Wallner, 18560 W. Evergreen Pl., New Berlin, WI 53151. Phone (414) 782-3935.

WANTED — Information or plans on building an observatory for 4-1/4" or 6" reflector telescope, and on building 6" telescope and mount. Would also like information on organizing an astronomy club. Write Roger H. Faucher, 19 W. Myrtle St., Biddeford, ME 04005.

WANTED — 12" or 12-1/2" reflecting mirror, f/6 to f/8, 1/4 wave or better. Aluminized or not. Contact Tom Giguere, 24762 San Vincente Ln., Mission Viejo, CA 92675. Phone (714) 830-3258.

WANTED — Good equatorial mount for 10" Cassegrain with clock drive, saddle and straps. Circles on rotating not a must but will take if price is right. Write James Hamilton, R.R. #2, Richmond, KY 40475.

WANTED — Free classified advertisements for Astro-Mart. You don't pay us a cent, but you'll be able to sell or find a variety of unusual (or ordinary) items through this innovative, reader service department. Send your ad to ASTRONOMY, Advertising Dept., 757 N. Broadway, Suite 204, Milwaukee Wis. 53202.

WANTED — 5" Celestron Schmidt camera and Celestron 5 scope. No mounting. Write Dennis J. Zywiczynski, 212 Strauss St., Buffalo, NY 14211.

In View of Vesta

More than twice Earth's distance from the sun, and well beyond the orbit of Mars, is the orbit of a world that is totally different from the nine planets familiar to every schoolchild. The globe that traverses that orbit is so small it cannot be seen from Earth without optical aid except by a sharp eyed observer who knows exactly where to look. That's the reason it went undiscovered until the beginning of the last century. But it is like its big brothers in some ways. It orbits the sun in an approximately circular path near the plane of the planetary system and behaves in general like a planet should.

This world is Vesta.

Since it is only 1/8 the diameter of the moon it's in a separate planetary class and is known as an asteroid. And strangely, Vesta is not alone.

The two largest asteroids orbit the sun in elliptical paths between the realms of Mars and Jupiter. Vesta requires 3.6 years for one trip around the sun and Ceres, with its larger orbit, takes a year longer. Vesta and Earth are about as close as they can get this month. Although not as large as Ceres, Vesta is nearer the sun and is made of more reflective rock, so it holds the title of brightest asteroid. Icarus is one of a small group of maverick asteroids that ventures within the orbit of Earth.

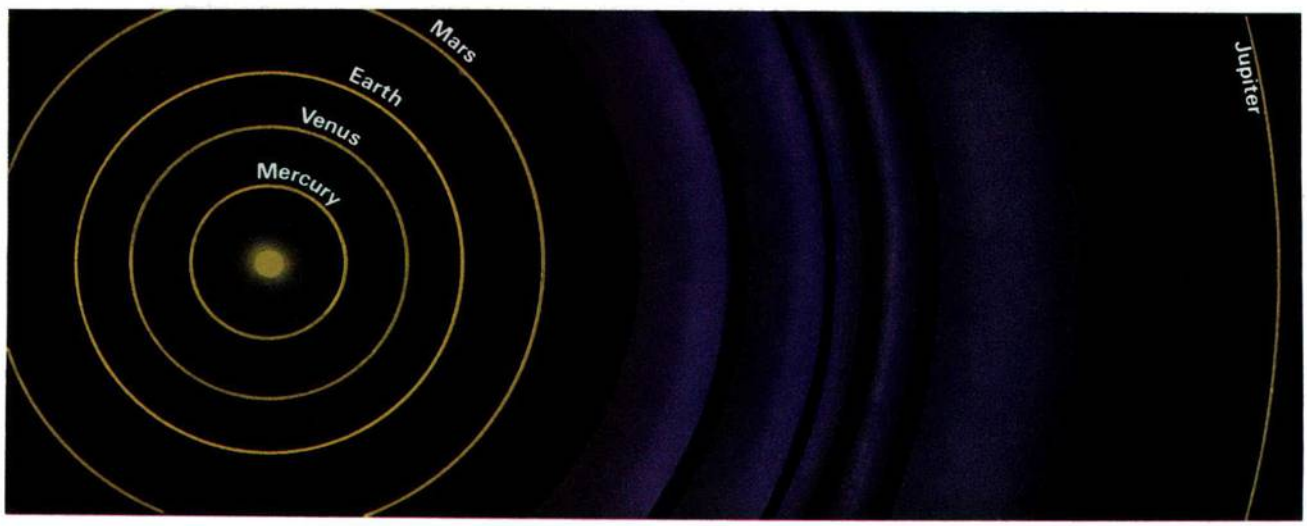


Diagram by Victor Costanzo

There are definite zones within the asteroid belt where the little planets cluster. However, these areas are not "packed" since even the most crowded regions average only one mile-wide asteroid for every 100 trillion cubic miles. The zones of preference (dark blue) are due to the disturbing effects of Jupiter's immense gravity. The asteroids have to find orbits that are at a compatible equilibrium with Jupiter.

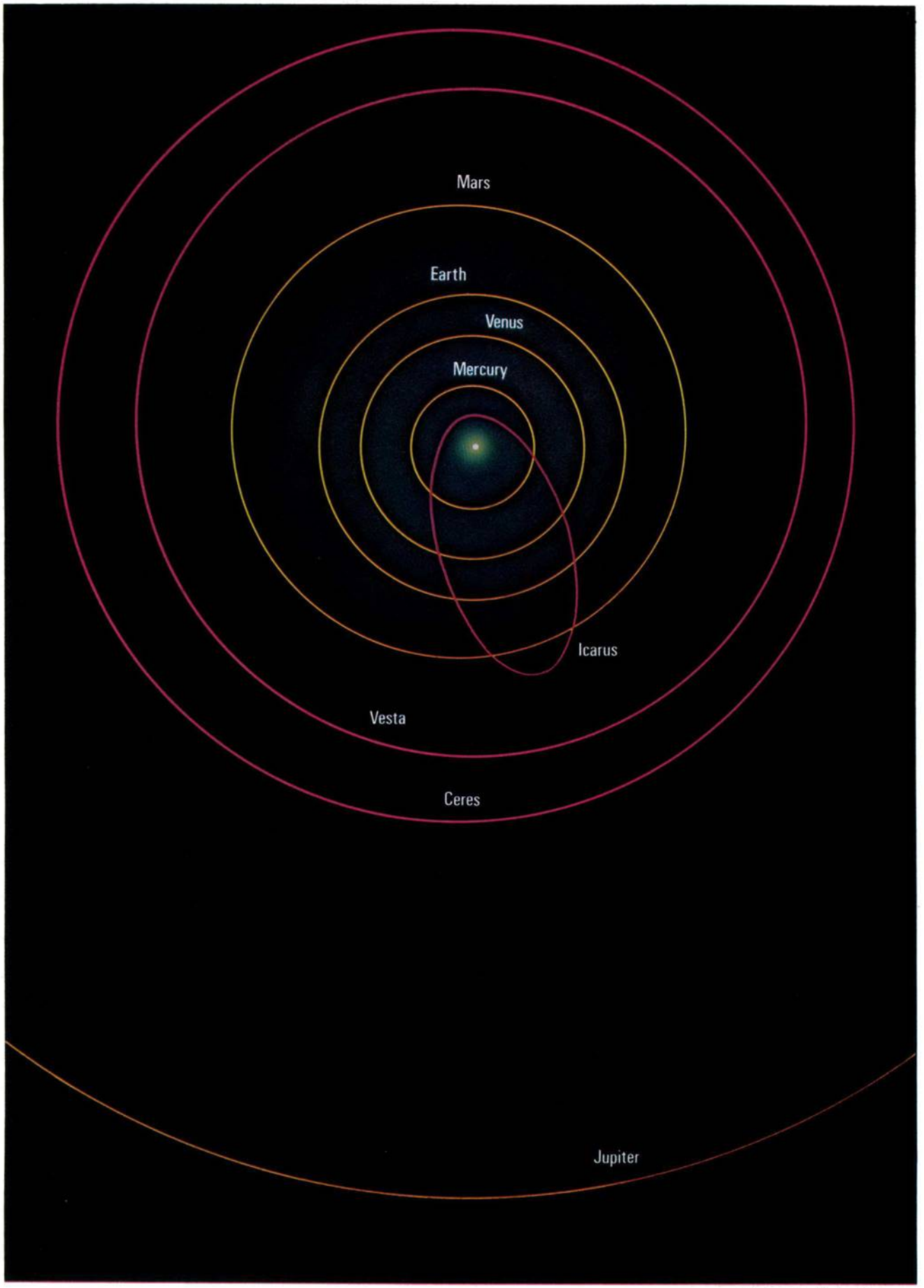
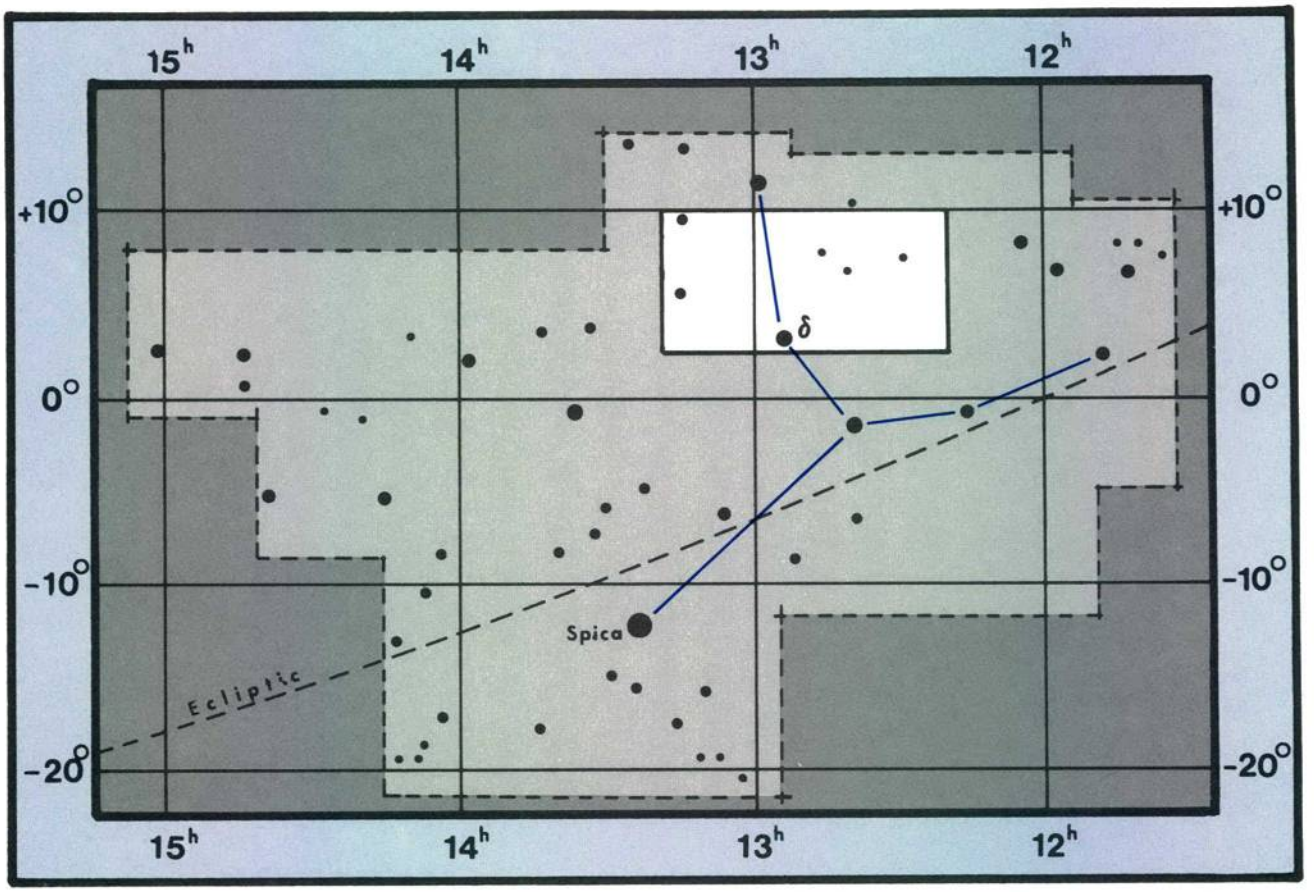
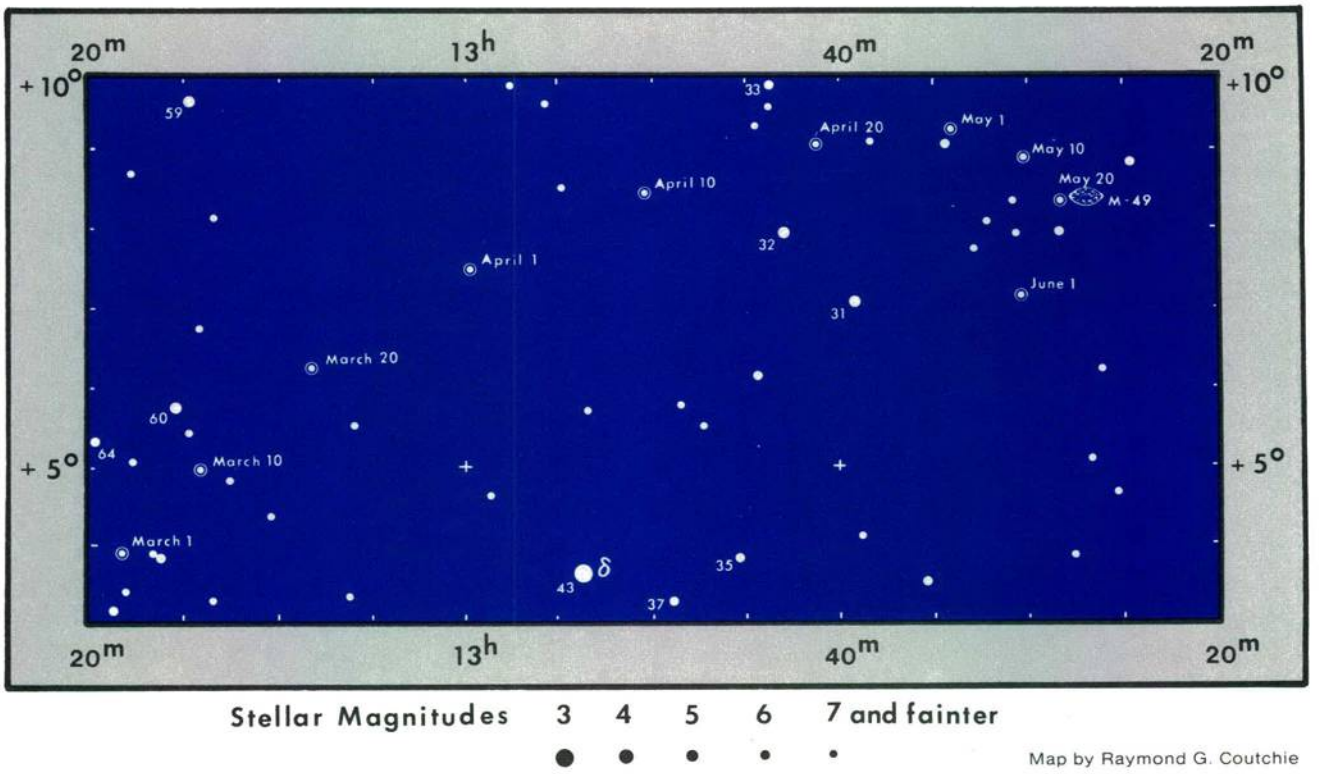


Diagram by Victor Costanzo



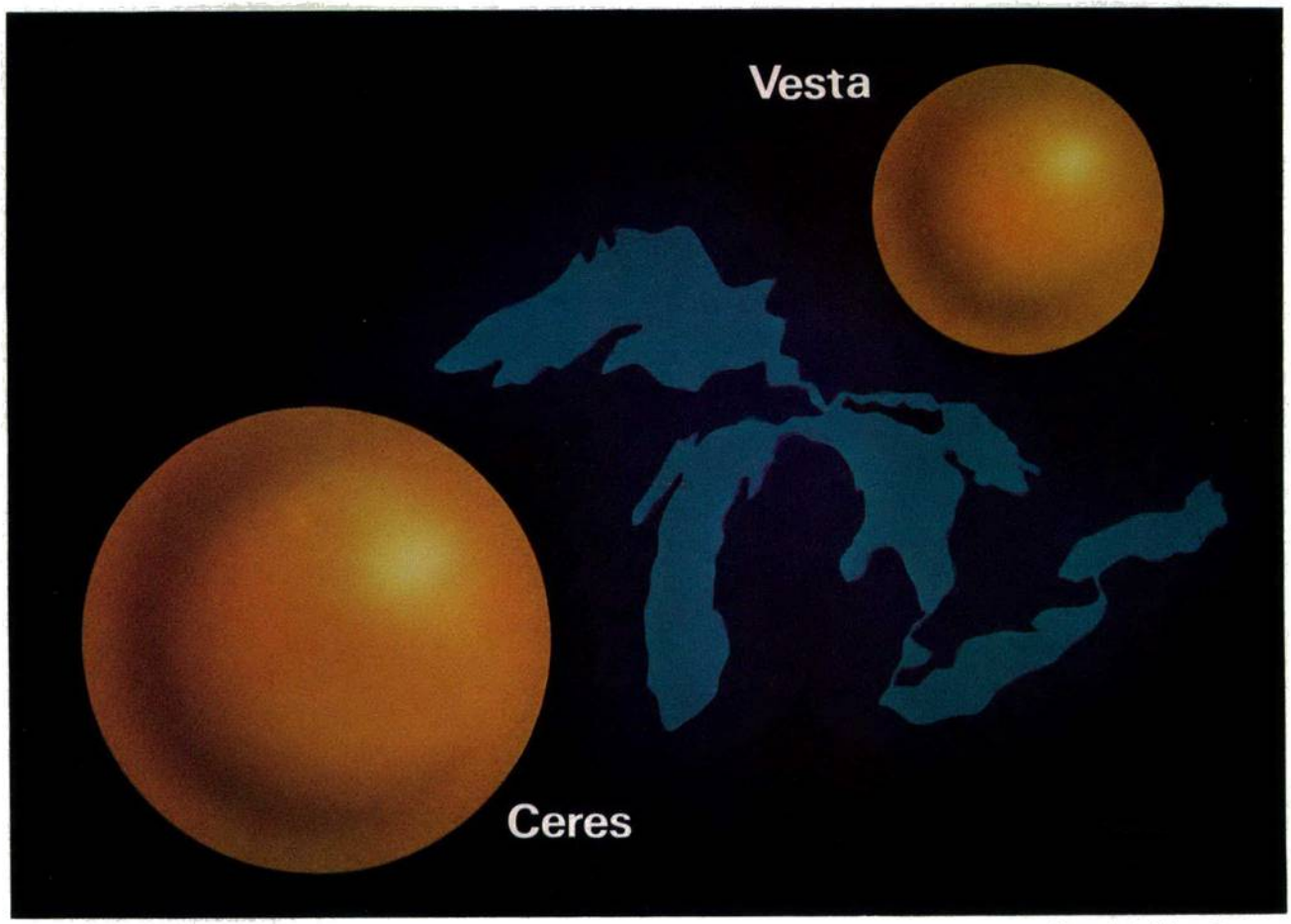
Vesta will be seen within the constellation Virgo in the spring of 1974. The distinctive "Y" of the constellation is the key to finding Delta, which is shown again in the detailed chart of the boxed area. Spica is a first magnitude star that is easily located in the eastern sky. See Star Dome for general orientation.



Stellar Magnitudes 3 4 5 6 7 and fainter

Map by Raymond G. Coutchie

This detailed version of the box in the finder chart shows positions of Vesta from March through June. On March 1 it will be magnitude 6.0, brightening to 5.8 by April 1, then dropping to 5.9 on May 1 and to 6.2 June 1. All stars on the chart should be within grasp of 7x50 binoculars; numbers beside stars are constellation designations. For example, Delta is also known as 43 Virginis. M-49 is a 9th magnitude elliptical galaxy.



Artwork by Victor Costanzo

The two largest asteroids dwarf even the largest of the Great Lakes. Detailed mapping of these two worlds will be a major project for future robot or manned space missions. Recent estimates are that Ceres is 600 miles in diameter and Vesta 330 miles across. Pallas, the other large asteroid, is about the same size as Vesta.

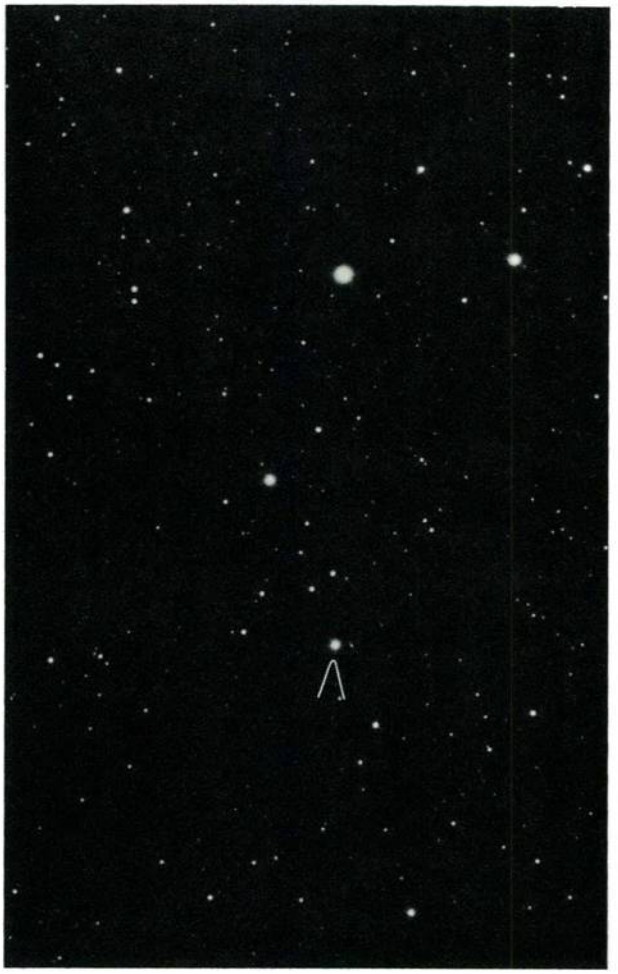
Thousands of asteroids roam the 300 million mile wide gulf between the orbits of Mars and Jupiter. Although not the largest asteroid, Vesta is the brightest one seen from Earth. This 330 mile wide planetoid takes 3 years, 230 days to complete one trip around the sun at an average distance of 219 million miles.

Suppose you could stand on this asteroid and look toward Earth. The sun would be significantly dimmer than we see it. Of the four inner planets, Venus would be a first magnitude star very close to the sun; Earth would be slightly brighter with the moon an easy naked eye object nestled beside it. Mars, although closer to Vesta, is a smaller planet and would appear about the same brightness as Earth during a good portion of its orbit.

Now let's take the more practical view from Earth looking toward the asteroid. The situation changes drastically. The small size of Vesta renders it invisible to the unaided eye (unless you know precisely where to look and have excellent eyesight). For this reason it, and its companion asteroids, remained undiscovered until the year 1801. In that year Ceres, the largest but not brightest of the asteroids, was discovered, and during the 1800s over 400 of these tiny worlds had their orbits charted. Except for Vesta all the asteroids remain below naked eye visibility and only a few of the largest (see table) are conveniently seen in small telescopes.

Although Vesta is not the largest of the asteroids it appears to be the most reflective of the major ones — bouncing back about 20 percent of the sunlight that falls on it. Most asteroids have moonlike reflectivity sending back less than 10 percent of the light that falls on them indicating that they are made of rather dark rock. Because Vesta seems to be lighter than the others and because its orbit is closer to the sun than the majority of asteroids, it is the one that is most easily visible from Earth. Binoculars are perfect for viewing Vesta during the next few months.

On March 30 Vesta is in opposition — that is, it is opposite the sun from Earth. This puts it at



Photographs by Raymond G. Coutchie

Vesta was photographed on a previous close approach to Earth by Californian Ray Coutchie. The two photos are 15 minute guided exposures taken 24 hours apart. A 10 inch f/4.5 lens was used with Kodak 103a0 film. The brightest star shown here is 5th magnitude; the faintest is 13th. Photos are about 1/4 of a degree wide.

its closest point to Earth during this orbit; therefore Vesta appears brighter in the sky at this time than at times when the two bodies are separated by greater distances.

During March and April Vesta will appear about sixth magnitude as it moves against the background of stars of the constellation Virgo. It's easy to find once you are familiar with the stars of Virgo. The easiest part of Virgo to recognize is the characteristic "Y" shape, with the bottom of the "Y" at Spica. The middle star in the left arm of the "Y" is Delta — the guide star for observing Vesta.

Once you have Delta centered in your telescopic or binocular field of view, simply find the other stars shown in the map accompanying this article and Vesta will be obvious. Binoculars will show most of the stars on the chart and any telescope will show these and fainter ones as well. Vesta will appear brighter than many of the chart stars so you shouldn't have much trouble finding it.

It's an interesting project to watch celestial motion in action from one night to the next. The change in Vesta's position can be observed telescopically or can be recorded on film. This too is easy to do. A telephoto lens attached to your camera, and the camera in turn attached to the side of your telescope will make an excellent combination for asteroid astrophotography. Have the telescope drive going and guide through the eyepiece of the telescope while the shutter of the camera is open. Make corrections with the telescope's slow motion controls. (If your scope is not equipped with slow motions on both axes, then asteroid photography is not for you.) The telephoto lens will record many stars in the region of this part of the constellation Virgo, and with the help of the chart you will be able to pick out the asteroid. Even in one night you can detect its motion.

What kind of worlds are these asteroids? Why is there more than one? Why isn't a big planet in the space between Mars and Jupiter that is occu-

The Brightest Asteroids

Name	Diameter (miles)	Average Distance from Sun (millions of miles)	Minimum Distance from Earth (millions of miles)	Maximum Magnitude
Vesta	330	219	107	+5.6
Ceres	600	256	144	+6.5
Pallas	330	258	103	+6.7
Iris	135?	222	78	+7.0
Juno	170	248	91	+7.3
Hebe	140?	226	86	+7.5
Eunomia	160?	245	106	+7.7
Flora	100?	205	80	+7.9
Melpomene	90?	213	74	+8.1
Metis	110?	222	101	+8.3
Bamberga	300?	250	72	+8.4
Massalia	100?	224	98	+8.4

pied by the asteroids? Why is Vesta more reflective than other asteroids? How many are there? As usual, the little bit that we do know about a particular celestial object raises many more questions, some of which can be answered, and many of which still cannot.

The total number of asteroids is unknown. They range from the giant Ceres down to bits of dust. There are an estimated 75,000 asteroids one mile or larger in diameter.

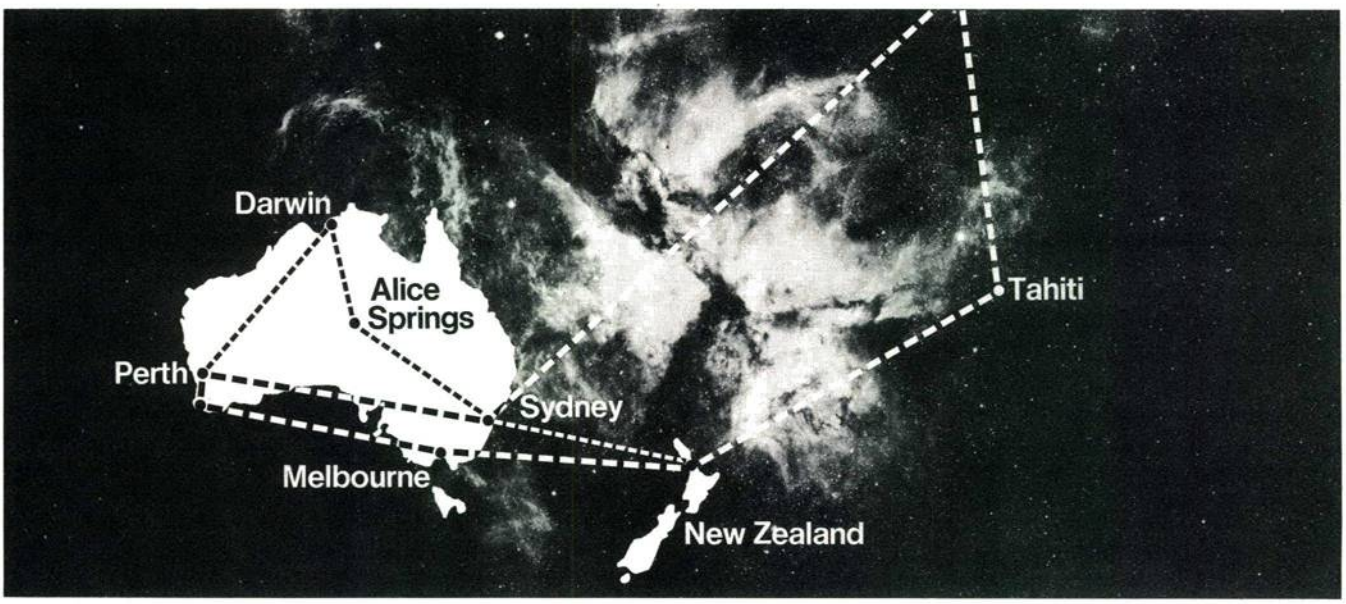
False notions have been perpetrated in many science fiction stories that inevitably include the asteroid collision or a near encounter with a "swarm" of asteroids.

Pioneer 10 passed through the asteroid zone on its way to Jupiter last year and found it had about the same density of particles as in the vicinity of Earth. So the "swarm" idea is false. There is so much space out there that average mile-wide asteroids will seldom get closer than one million miles from each other — hardly a swarm! If we again take our view from Vesta we would be lucky if even one other asteroid would be visible to the unaided eye.

Another common misconception about asteroids concerns their origin and the idea that one planet formed in the region between Mars and Jupiter and then broke up to create the asteroids. This concept is now very unpopular among planetary scientists mainly because Ceres, Vesta and the few other large asteroids are spherical and seem to have been formed as separate objects.

Possibly there were less than a dozen planets where the asteroids now roam. Some of them collided, smashing into thousands of smaller bodies. So there may be two classes of asteroids: the originals and the fragments. It is thought that the meteorites that occasionally plunge to Earth are asteroid fragments.

The smaller asteroids have irregular shapes, lending support to the fragment idea. These shapes are observed as light fluctuations as the asteroid rotates. Many are brick shaped and thus appear brighter when seen from the side than when they are end-on. Vesta, although very nearly spherical, does have a slight variation in brightness during its 10.7 hour rotation period. By observing Vesta's variability with great precision, astronomers have found its axis is tilted at very nearly the same degree as Earth's axis. Other experiments have shown that Vesta is composed of basaltic rocks and is probably denser than most of the moons in the solar system.



George Abell, George Bunton, William Kaufmann and Paul Routly say, *"Come with us to explore the Southern Skies."*

Today, as modern astronomers, we are face to face with those problems which for centuries have inspired men to ask the most fundamental questions about the nature of the universe: its origin, its evolution, its future. important clues to help answer these questions lie in many objects that can be observed only from southern latitudes.

Join us in our exploration of the Southern Skies. We have a full course in Modern Astronomy ranging from the nature of eclipses to the expansion of the universe. Our expedition will include a stopover in southwest Australia at the best land site available to view the eclipse of June 20 (four minutes totality). We shall see how the Polynesians navigated the waters of the Pacific and examine such sights as Omega Centauri, Eta Carinae and the Clouds of Magellan from the beaches of Tahiti and Bora Bora.

George A. Abell

Professor and Chairman, Department of Astronomy, University of California, Los Angeles. Guest Investigator, Hale Observatories.

PhD, California Institute of Technology, 1956. Author of *Exploration of The Universe*, the leading college text in astronomy plus many scientific papers and popular articles; Specialist in research on clusters of galaxies and observational cosmology.

"Its hard to imagine the beauty of the southern Milky Way until you see it in person. The South Sea Islands and Australian wine are also hard to beat. I am anxious to go back and introduce the Southern Skies and my friends from 'Down Under' to our group."

George W. Bunton

Manager, Hawaii Science Center, and Planetarium Director, Bishop Museum, Honolulu, Hawaii. Formerly Lecturer in Astronomy, University of Hawaii; Manager of Morrison Planetarium, San Francisco.

BA, University of California, Los Angeles, 1942. Author of more than 50 articles on astronomy and astronomical instruments; Specialist in celestial navigation and solar eclipses.

"Our Museum is the center for study of Polynesian culture and history and my interest is in their use and understanding of astronomy, particularly for navigation. We can have a navigation workshop on Bora Bora and compare the ancient techniques with modern technology."

William J. Kaufmann

Director, Griffith Observatory, Los Angeles; Lecturer in Astronomy, University of California at Los Angeles, University of California at San Diego, University of California at Riverside, Claremont Colleges and University of British Columbia. Formerly NSF Post-doctoral Fellow, California Institute of Technology, Pasadena, California.

PhD, Indiana University, 1968. Author of *Relativity and Cosmology* and numerous scientific and popular articles: Specialist in relativistic astrophysics.

"I want to relax with our group on the beach by day to talk about things of mutual interest and observe the heavens by night and talk about my unique interests."

Paul M. Routly

Director, Astrometry and Astrophysics Division, United States Naval Observatory, Washington, D.C. Formerly Executive Officer, American Astronomical Society; Professor of Astronomy, Pomona College, Pomona, California.

PhD, Princeton University, 1951. Co-author of the major advanced astronomy text on our own galaxy, *Galactic Astronomy* and author of many scientific papers; Specialist in instrumentation and atomic and nuclear spectra research.

"A large part of the thrust of Modern Astrometry is centered on the Southern Skies. The future is there and I'd like to share my enthusiasm and the reason why this knowledge is essential."

On Friday, June 14, 1974, our expedition to explore the Southern Skies departs for Honolulu and Sydney via QANTAS Airlines. Included will be a Trans-Australian trip to view the total eclipse of the sun on June 20, a stay in Melbourne and Canberra, a lay-over in Auckland on our way to Tahiti, and a trip to Bora Bora. A select few can take the journey from Darwin to Alice Springs into the heart of the Australian "Outback." Our scientific advisors will be along throughout the trip.

ACADEMIC CREDIT is available through the UCLA Extension Division.

23 days from $2190
West Coast to West Coast

For information call (213) 478-0989 or write
WESTWIND Travel & Tours, Inc.
11749 Wilshire Blvd., Los Angeles, CA. 90025.

Please send me information regarding the expedition to explore the Southern Skies.

Name:_____

Address:_____ Phone ( )_____

City:_____ State:_____ Zip:_____

ASTRO-NEWS

Latest News From the World of Astronomy

Center for UFO Studies Established

Over the last quarter century hundreds of thousands of unidentified flying object (UFO) reports have been received by various private and government agencies. The unexplained content of many reports from credible witnesses from all parts of the world continues to present a modern scientific enigma.

"Any phenomenon which has occupied the thought of so many people for so many years is surely worthy of serious scientific study," says J. Allen Hynek, probably the world's foremost authority on the subject. "The UFO phenomenon has not been given serious attention in the past," Hynek insists, "yet it is an incontrovertible fact that a great many unsolved UFO reports exist."

Hynek, chairman of the astronomy department at Northwestern University, says the phenomenon has been the subject of misconceptions, misinformation, and an unscientific approach. To help rectify the situation Hynek and a group of selected scientists have established the Center for UFO Studies "for those who wish to see positive scientific action taken to end a quarter of a century of misrepresentation and buffoonery."

Hynek believes the evidence is strong that the UFO phenomenon represents new empirical observations of great potential value to mankind. The work of the Center is directed toward discovery of the essential nature of the UFO phenomenon.

Hynek has disputed the scientific validity of two major UFO studies conducted so far — both government sponsored projects. One, the so-called Condon report, is based on the two year research of a group of prominent scientists headed by Dr. Edward Condon, a noted physicist. Although the negative conclusions of the Condon report (suggesting UFO's receive no further study) were widely circulated in the press, Hynek and others have found that 25 percent of the cases studied remain unexplained.

The other major study, Project Blue Book, was "a cosmic Watergate, or else gross incompetence" according to Hynek who was its scientific consultant for 20 years. "Many interesting cases with scientific potential were disregarded," he said. Of the Blue Book cases, 20 percent were unexplained — yet the project was closed in 1969 on the basis of the Condon conclusions.

The Center for UFO Studies defines a UFO as "the reported perception of an object or light seen in the sky or upon land; the appearance, trajectory, and general dynamic and luminescent behavior of which do not suggest a logical, conventional explanation, and which is not only mystifying to the original percipient but remains unidentified after close scrutiny of all available evidence by persons who are

UFO Center

continued on page 48

Meteorites Reveal Carbon Molecules

More evidence that life on the primitive Earth may have been triggered by chemical evolution of nonliving matter has been uncovered by a team of National Aeronautics and Space Administration scientists at NASA's Ames Research Center. In studies to find links between living and nonliving matter, the team of researchers has discovered 17 varieties of fatty acids in two recently examined meteorites. The fatty acids are similar to those used by plants and animals to produce even more complex biological molecules, and are commonly found in household staples such as milk, margarine, fruits and vinegar.

The fatty acids were found in tiny samples of the Murray and Murchison carbonaceous meteorites. Because the samples were taken from the inside of the meteorites under scrupulously clean laboratory conditions, the chances that the acids are the result of terrestrial contamination are remote.

Some of these basic building blocks of life have been produced in the laboratory by other scientists. In these experiments, energy was applied to a mixture of chemicals such as methane, hydrogen, ammonia and water, which is thought to be similar to the atmosphere of the newly-formed Earth. The product of the experiment was a mixture of relatively complex molecules, including simple amino acids and at least 9 of the 17 fatty acids isolated by the Ames scientists.

The family of simple carbon-hydrogen acid molecules found in the meteorites has counterparts in biologically-formed Earth materials, but they have never been found in non-organic sources like rocks. The mystery is how an extraterrestrial rock — a meteorite — could contain these materials which are basic to the biology of plants and animals.

Though the total amount of the substances examined is extremely small — a ton of similar meteorite material might yield 1/2 pound of the fatty acids — their existence is a new clue to how the evolution of nonliving chemical compounds has provided nature with the essential building blocks of living materials.

The Strange Case of

Guest Opinion by

Frankly, I have enjoyed watching the way the approach of Comet Kohoutek affected people in the United States. The time was ripe. We all needed a cosmic harbinger of good news although some used it to herald bad news. Basically 1973 was a very bad year for the peace of mind of millions. Watergate, the war, the economy, the fuel crisis, and a host of presidential scandals rocked us all. Would there never be an end?

The word leaked out that astronomers knew about a comet that had been spotted far from Earth, so distant from the sun that early predictions suggested it might well be one of the brightest comets of the century. From the start of the comet lunacy there were those cautious realists, used to the vagaries of comets, who reminded us that these predictions were at best very hazardous guesses. They were ignored. Although early reports in the media did remind us of these uncertainties, later reports pushed all uncertainty aside as the comet, still only seen in the largest telescopes, continued to brighten. Forgotten were the warnings that comets often break up, some simply do not even survive the close approach to the sun, and others die out rapidly after their visit to the solar neighborhood. These were all forgotten because the world was ready for the comet no matter what. We really needed a comet at the end of 1973.

This need had earlier been reflected by an incredible spate of UFO sightings. One can almost refer to that series of sightings as a panic. Everyone was into the act; it took our minds off the chaos in this country. And then the comet. We could plan for this one. Many very esoteric ways were dreamt of for getting a lot of escapist miles out of this comet. Electronic music concerts were held all over the country. Impromptu recording sessions and rock sessions were held to celebrate the arrival of Kohoutek. We wanted to express a welcome to our heavenly visitor, and it was most welcome.

We certainly all hoped to see it streak across the sky, as so many oracles had predicted it would. Unfortunately comets do not streak across the sky at all. No comet has ever streaked across the sky. Meteors, yes — they streak across the sky. But comets simply hang up there, and by the next day have moved a little. They might lumber across the sky, but streaking — definitely not! And yet that is what the public was told; people came to open houses at observatories looking for an object with a glorious tail streaming out behind it. Those astronomers who took it upon themselves to inform the media so that the good word was spread also failed to point out that the tail of a comet is hardly as bright as the head, even if the head was to live up to its advance billing.

And so we continued with the false advertising campaign, no doubt quite in accordance with the times. No doubt the two words "Comet Kohoutek" were the most used words as far as any scientific terminology is concerned. Perhaps for a while, these two words were printed or spoken more often even than "Halley's comet" or "Watergate". This comet simply had to live up to its greatest predictions, or we would again have to face another hard reality — that things aren't always what they seem to be.

Everybody who thought he was anybody wrote about Kohoutek. Every magazine worth its salt published something. Every amateur celestial mechanic predicted orbits, times to view the beast, likely magnitudes, etc. Timothy Leary, from his jail cell, sent us a warning; the children of God sent their warning; many others were genuinely frightened at the possibilities of further disaster that might accompany this alien from space. Television programs that reminded us about the associations between other comets and pestilence, wars and the black death didn't help to quiet the fears that many felt.

These fears together with the enormous publicity that the comet did get were not the makings of some super public relations man in the astronomical community. Rather, I take it to indicate the mood of the nation during 1973. We really needed this visitation and, "by-the-cosmos", we were not going to be cheated. But we were!

I personally have had nothing but traumatic cometary experiences. Trauma here is defined as arising at three on a cold morning, driving out of town, scanning the heavens with binoculars for two hours and then returning to what little sleep was still possible. Never did I see anything. This time I did however. I did see Comet Kohoutek!

The first time was through a 24 inch telescope at 5:00 a.m. looking directly over the lights of Denver, Col. I still don't know which was less exciting to look at, the comet or the star in the field of view. There was no difference in appearance between them at this time. Later I saw it again, this time through a five inch telescope. Again it looked little different from a blurred star, but it was orange in color as it struggled to shine through the dust and haze over the mountains. By this time it was about six magnitudes below original realistic predictions. No one that I know saw anything worthwhile with the naked eye. And even as it died out very fast no one came out and said so in the press. A small sentence lost in a story about Skylab was all I saw; it stated that it was too faint for the instruments on board Skylab to pick up. And that was when its brightness should have been comparable to that of Jupiter! No one told anyone. We all had to find that out for ourselves, which is one of the joys of science. We need to test our predictions by observations. And our observations this time have shown the theory to be wrong.

But the man on the street doesn't know this, so he turns up in hundreds

Comet Kohoutek

Gerrit L. Verschuur

at local observatories and has to be told that Comet Kohoutek, like 1973, turned out to be a big bust. He turns away and mutters, "I'll never believe those astronomers again", half in jest, but half seriously.

And I wonder, how did it all happen? So many of us know that astronomy is hardly infallible. We can predict eclipses with certainty, but there is very little else that can be stated with such complete confidence that another observation or two will not prove us wrong.

But still, Comet Kohoutek did provide a useful advertising aid to many. Telescopes, binoculars and books on astronomy were sold in larger numbers. Even when Kohoutek was seven magnitudes below predictions a full page advertisement appeared locally for telescopes which could pick it up out there in the dark evening skies, with magnitudes given as well as helpful hints on where to look. Might as well scan the skies for a new comet than try to look for Kohoutek by the time this ad appeared! It would then be named after you and your new telescope would have been a really great investment. But at least now you have a telescope and you can get turned on by the more perennial marvels out in space: the moon, planets, nebulae, galaxies and asteroids.

Why did Comet Kohoutek get so much coverage? I believe its time was ripe. There have been other naked eye comets in the last 10 years, but this one was found well before it was bright enough to see. This meant that the word could really get around.

Personally, I doubt whether that is the whole story. I think as a nation we needed a saviour, even if it only visited for a few weeks. And so we all turned to Kohoutek, bringer of good or bad messages, depending on your turn of mind. After all it is not every day that a glorious streak of light hurtles across the sky, like it seems to do in the photographs we saw. No one took too much trouble to point out that those photographs were long time exposures and no eye would ever see the tail twisting out in streamers the way it seemed in the photos. No one really told the truth about what might be seen, even if Kohoutek lived up to predictions made in late November. And there were even those astronomers who would say to a local newspaper that despite the indications that Kohoutek was not as bright as predicted, they still hoped the comet would live up to expectations. Such hopes may be held, but too many interpret the hopes of some as likely reality. It is irresponsibility to get on the bandwagon and loudly proclaim the joyous coming, while only whispering under one's breath that things might not pan out the way we hope.

On the brighter side the comet has been very closely studied, and very successfully studied, by scientists using all sorts of telescopes; these data will be tremendously useful in understanding future visitations. Some historic firsts have been achieved. Molecules were found in the comet using radio telescopes. No doubt other data will soon be forthcoming which will amaze and fascinate us. Also, many amateur astronomers and other dedicated comet viewers have seen Kohoutek with their binoculars and have been thrilled by it. But that is not the point. We were all supposed to see this one stretched out across the sky.

Someday someone might try to understand just why Kohoutek was so popular. Perhaps a few hundred years from now, writers describing the arrival of another truly great comet will review the history of comets and remind mankind that the comet of 1973-74 was correlated with the great crisis of the U.S. in those same years. In the meantime we readily forget Comets Bennett, Ikeya-Seki, Arend-Roland and others which came in quiet and peaceful years, but which were far brighter than Comet Kohoutek.

New X-Ray Observatories Planned

Based on recommendations of the scientific community and the National Academy of Sciences that high energy astrophysics research should receive very high national priority, the National Aeronautics and Space Administration has undertaken a program called HEAO (High Energy Astronomical Observatory).

The first observatory, HEAO-A, will be launched in 1977 to perform a detailed X-ray survey of the celestial sphere. HEAO-B will carry an X-ray telescope and will be launched in 1978 to point precisely at the most interesting X-ray objects in the sky and analyze their radiation. HEAO-C will be launched in 1979 to perform cosmic ray and gamma ray observations. HEAO-C and following payloads may be carried by the Space Shuttle.

The initial HEAO observatories will be launched into a 225 nautical mile orbit from NASA's Kennedy Space Center by Atlas Centaur boosters. Each 18 foot long observatory will weigh 6,000-7,000 pounds, provide electrical power from solar arrays, and carry over 1-1/2 tons of experiments. The observatories are expected to be capable of greatly increasing our knowledge of the nature of black holes and pulsars — prime sources of X-ray radiation.

TRW Systems, a major designer of space vehicles, is building these observatories that will ultimately push back the frontiers of man's knowledge. TRW is also on the forefront of public education. Their recent booklet "Quasars, Pulsars, Black Holes. . .and HEAO's" is an excellent indication of this. It may be obtained by writing to Mr. Don Bane EZ/9085, TRW Systems, Redondo Beach, Calif. 90278.

ASTRO-MART

Free Classified Ads For Subscribers

only in ASTRONOMY

UFO Center

continued from page 45

technically capable of making a common sense identification, if one is possible."

There exists a growing number of scientists, engineers and other professionals generally associated with universities, laboratories, and industry, who have contemplated the possible significance of the UFO phenomenon. They noted that such significance to science and society was being totally obscured by the popular confusion and gross misconceptions regarding the UFO phenomenon. The Center provides an avenue whereby the interests and talents of these scientists and other professionals can be focused and brought to bear on this challenging problem. A significant number of them have become actively associated with the Center and have volunteered their talents and facilities.

According to Hynek the Center has four principal objectives: 1) to pursue a rigorous study and analysis of the UFO phenomenon, calling upon the talents and services of the Center associates and employing existing facilities (computers, physical and biological laboratories, etc.) at universities and in industry wherever possible. While the ultimate objective of the Center is solution of the UFO enigma, should this not lie within our present scientific rubric, then at least this phenomenon which has figured so prominently in modern history should be documented and the data organized as thoroughly as possible; 2) to operate UFO CENTRAL, a clearing house to which persons can report UFO experiences without fear of ridicule or unwanted publicity, and with the knowledge that such reports will be given serious attention; 3) to provide bulletins and technical reports, and be a source of reliable information about the UFO phenomenon to schools and universities, scientific organizations, and the public in general; 4) to assist and help guide correlative studies conducted in the United States and elsewhere through international symposia and conferences. (It is not generally known, for instance, that active work in this field is being pursued on several continents.)

"The UFO problem clearly involves aspects of interest to psychologists, sociologists, and medical men, as well as to physical scientists and engineers," notes Hynek. He remarks that there has rarely been a subject so interdisciplinary in character.

To accomplish its objectives, the Center has access to modern electronic computers so that a central bank for UFO data can be maintained, queried, and updated. Information theory and modern methods of information retrieval, pattern recognition, etc., are used to establish patterns and correlations between various UFO parameters (time, place, demographic factors, witness reliability, types of sightings, etc.).

A constant problem in UFO research has been unscientific reporting and data collecting. To alleviate this critical problem a toll free, nationwide telephone number has been made available to law enforcement officers across the country, and to other responsible organizations on a 24 hour basis. This enables the Center to be quickly apprised of UFO events, to make preliminary evaluations, and dispatch local investigators to the scene. The number is not to be used by individuals but only by civilian or government agencies and organizations. However, the number is being made available to the readers of ASTRONOMY so that they in turn can supply it to local police officials, airport control towers, civilian defense agencies and officials of other responsible organizations. The number is (800) 621-7725.

EARTH VIEW

NASA Photograph

Earth, from one million miles, is portrayed by one of Mariner 10's two television cameras as the spacecraft heads for Venus and Mercury. This is the first time our planet has been photographed from farther than the moon's distance (about 250,000 miles). Taken Nov. 6, 1973, the picture shows Earth more than filling the TV camera frame. Most of North America is out of frame at top. The west coast of South America can be seen in late afternoon sunlight from center right to lower right. Mariner 10 will photograph both Venus and Mercury from much nearer than this.

It has been established that a UFO sighting represents a very real event, and often a very frightening experience, to persons involved. The existence of UFO CENTRAL and its close association with police departments, civil defense and various aviation agencies, provides a ridicule-free avenue for the natural desire on the part of witnesses to communicate their experience with so startling an event.

The Center's main efforts are directed toward specific problems arising from reported UFO cases. The large number of cases in which UFO's have been reported to have interacted with the environment presents a scientific toehold not available in the equally spectacular cases in which nothing has been left for study except the detailed report of the witnesses.

The research of the Center would concern itself with the credibility of witnesses, medical examinations of persons and animals affected, laboratory analysis of residues associated with a UFO close encounter (e.g. plant and soil samples), photographic analysis, theoretical studies of the dynamic and luminescent properties exhibited by UFOs, and statistical and correlative studies of UFO events involving geographic, demographic, and parametric aspects.

The problems studied are the intriguing problems and experiments suggested by the consensus of UFO reports — not just the UFO itself. A visitor to laboratories associated with the Center might find it hard to discover that the problems being studied and the experiments being performed had any direct connection with UFOs.

Persons interested in furthering serious scientific work on the UFO problem can participate best by volunteering their technical services and facilities, or by making tax deductible contributions to the Center for UFO Studies, P.O. Box 11, Northfield, Ill. 60093.

ASTRO-MART

FREE CLASSIFIED ADS
to ASTRONOMY subscribers only.

As a noncommercial subscriber you receive two free 40 word classified ads each year as a privilege with your subscription. Commercial advertisers must pay for their ads; rate cards are available on request. Write

ASTRONOMY, Astro-Mart Advertising, 757 N. Broadway, Suite 204, Milwaukee, WI 53202.

Water Molecules in Kohoutek's Tail

The first evidence of water molecules in a comet has been discovered in Kohoutek by two Canadian scientists. Dr. Gerhard Herzberg, a 1971 Nobel Prize winner in chemistry, and Dr. Hin Lew of the physics division of Canada's National Research Council report that they have identified electrically charged water molecules in Kohoutek's tail.

"This is one of the most important findings thus far," said Dr. Steve Maran, a comet expert at Goddard Space Flight Center, "and it reinforces our belief that Kohoutek is, scientifically speaking, the most important comet since Halley's even though it's much dimmer than was originally expected."

Herzberg and Lew analyzed emissions of light at five specific wavelengths in the red region of the comet's spectrum. These data were obtained by astronomers using ground based telescopes at the Asiago Astrophysical Observatory in Italy and at the University of California's Lick Observatory. Two of the five emissions had been found in a 1963 comet, Comet Ikeya, but they were not identified as water molecules until these findings from Kohoutek.

Dr. Fred L. Whipple of the Smithsonian Astrophysical Observatory, the man who originally predicted the presence of water in comets in his famous "dirty snowball" theory (speculating that comets are composed of a frozen ice nucleus, various other frozen gases and tiny dust particles), says he is "extremely gratified" by the finding.

Here is how the data were obtained:

As Kohoutek moved toward the sun, it was heated and the ice in its outer layers turned to water vapor or steam. Then solar radiation ionized the water vapor molecules, causing them to lose electrons and gain a positive electrical charge. Once the molecules were charged, the solar wind (plasma particles that constantly stream away from the sun) pushed the molecules back away from the sun and into the tail of the comet. At this point the molecules produced the red light observed by telescopes and spectrographs.

Earlier in Operation Kohoutek, scientists, using a special antenna at the National Radio Astronomy Observatory, reported finding hydrogen cyanide and methyl cyanide in the comet. These two chemicals have never before been observed in a comet and their presence in Kohoutek is consistent with the theory that comets may have been formed by aggregation of interstellar dust grains large distances from the sun, indicating that comets may have originally formed beyond the confines of our planetary system.

New Means to Harness Solar Energy

Black is not only beautiful, it can be a veritable sponge for the sun's light. A Pennsylvania scientist has made use of this principle in developing the preliminary design for a new way of harnessing solar energy that could speed the day when "solar farming" can generate electric power for large cities.

His "sponge" is graphite, which soaks up about 90 percent of the visible light that reaches it. In this proposed new method, developed by Dr. Howard Palmer of Pennsylvania State University, a thin slab of graphite would be installed in a long, well insulated pipe through which helium gas is pumped. The sun's rays, concentrated by mirrors, would pass into the pipe through a window and be absorbed by the graphite. The resulting heat would naturally transfer to the flowing helium. Heated to about 1100 degrees, the helium from a network (or "farm") of pipes would drive a gas turbine coupled to an electric generator.

"This scheme," says Dr. Palmer, "involves no fuel, no pollution or waste, uses no water, and is relatively thrifty in land use."

Such a farm on a 4 x 5 mile parcel of desert could provide a thousand megawatts of power, enough electricity for a city of 200,000 inhabitants at present rates of consumption.

Dr. Palmer estimates that the "graphite sponge" technique, combined with the use of a gas turbine, could produce power from the sun at about twice the cost of conventional means. "However, this could change with a change in our attitude toward solar energy. Until very recently virtually no research money had been spent on the subject. With increased funding in this area, there is real hope that efficiency can be improved and a graphite-type gas turbine solar farm can be made competitive with conventional power."

The Palmer system would convert solar energy to electrical energy at an estimated 12 percent efficiency which is comparable to efficiencies achieved by other solar-thermal systems. "The relative technological simplicity inherent in the graphite system, however," says Palmer, "would seem to be in its favor."

Palmer envisions solar farms in desert areas or even on man made islands located 40 or 50 miles off the California coast, where there is plenty of direct sunlight most of the year and where electrolytic production of hydrogen from sea water would be very convenient. The hydrogen would be used as a substitute for natural gas.

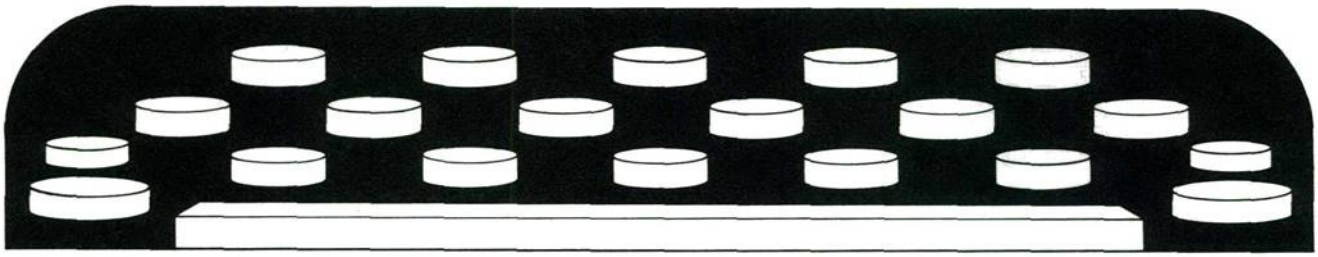
Moon Reflectors Still Used

Remember the laser reflectors the Apollo 11, 14 and 15 astronauts left on the plains of the moon? Observations of laser beams fired from Earth and reflected off these devices have now been refined to incredible accuracy.

Working at several observatories around the world, astronomers have precisely timed the 2-1/2 second round trip for the laser pulses during over four years of tests. The results have refined the earth-moon distance to a remarkable six inches!

Since the distance to the moon varies by 30,000 miles each month, due to our satellite's elliptical orbit, the measurements are only averages. But statistically the accuracy of our knowledge of the orbital interactions of these two worlds is increasing daily. A precision of one inch over the quarter million mile gulf between Earth and moon will be detectable in a few years.

Practical applications of this new data include possible measurement and proof of continental drift and polar wandering, both of long term value in climate and earthquake investigations.



Sir / In reading the memo in your December issue apologizing for the errors in the November issue of ASTRONOMY, I could not help but notice the conspicuous absence of a mention of one faux-pas in particular which may have caused other readers, besides myself, some confusion. I am referring to the caption of the Andromeda nebula on page 6 which states that the galaxy is a "city of 250 million stars".

Since this figure seemed somewhat low, I consulted several astronomy texts which placed the stellar population of our neighboring galaxy at between 100 and 400 billion stars.

Which is correct?

PHILIP L. PLANTE
Rockville, Md.

Mr. Plante / The correct figure is 250 billion stars. Thanks for bringing this error to our attention.

Sir / After previous futile tries on Dec. 29 and 31, 1973, I located the Comet Kohoutek on Jan. 2, 1974, at 5:35 p.m. EST. I found it approximately 11 degrees above the west-southwest horizon, and estimated its magnitude at about +2; but due to the brightness of the sky, it could have been as high as +0.5. There were unfortunately no nearby stars to use as comparisons, and the tail was nearly invisible except near the head.

An interesting note here for other astronomy enthusiasts like myself: try looking for Venus at the next eastern elongation when Venus is near maximum brightness during the time when the sun is above the horizon. On Dec. 29 and 31, I saw Venus 15 minutes before sunset; on Jan. 2, I glimpsed it a full 35 minutes before!

MARK SHAPIRO
Levittown, Pa.

Mr. Shapiro / You are among only a handful of people who saw the comet on Jan. 2. Clear skies and an unobstructed horizon were prerequisites for its observation.

Sir / On the evening of Jan. 5, Steve Bertelli, Brian Twohig, Doug Kimball and I set up an observing station on the roof of the Springfield Museum of Science to observe Comet Kohoutek. On a half dozen previous attempts before perihelion we had been unsuccessful due to fog and pollution in the early morning sky. Armed with cameras, binoculars, and a three inch refractor, we began searching at about 4:45 p.m. After 45 minutes of fruitless efforts, I finally spotted a fuzzy star in 7 x 50 binoculars. Using averted vision, I could see a silvery white tail about 3/4 of a degree in length. The nucleus could easily be distinguished as a rather bright pinpoint of light.

We quickly converged on the museum's 20 inch Schmidt-Cassegrain telescope, and within minutes we had Kohoutek in the field at 250x. Through the 20 inch, no tail at all could be detected. Instead the comet appeared as a nebulous patch about one minute of arc in diameter, with a very bright nucleus visible during moments of good seeing. Although Kohoutek soon became invisible in binoculars, we were able to track it in the big telescope until it set behind the roof of a distant building.

Later that evening we answered hundreds of phone calls concerning Kohoutek. Although most people could identify Venus, many thought that Jupiter was the comet. Many people also saw the contrail from an airplane low in the west and thought that this was the "great comet".

A gentleman called and said he was very pleased with the comet which he had observed with his naked eye. He described it as being twice the size and brightness of the moon, with a long and fiery tail. I don't know what he saw, but it certainly wasn't the same comet that I could just barely see in binoculars.

Still another gentleman called to report that he saw a bright blue light moving down his street with a red flashing light on it. He wondered if this was Kohoutek.

All in all, the comet was a disappointing sight. Instead of observing the "great comet", we turned our telescope on Venus which, in my opinion, was a much more spectacular sight.

RICHARD SANDERSON
Springfield Museum of Science
Springfield, Mass.

Mr. Sanderson / Your experiences with Kohoutek are similar to many others that we have heard about. It was very difficult to put the comet in its proper perspective after the huge build-up it received.

MEADE means precision in optics.

Model 133 2.4-in
The matchless refractor of its size.

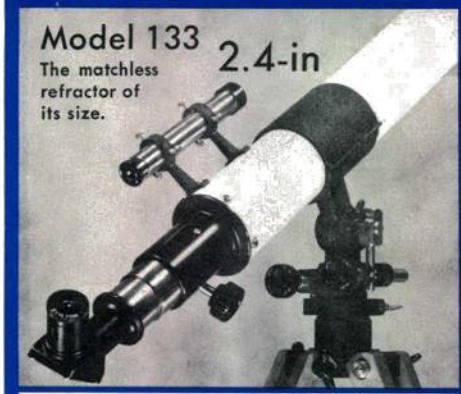
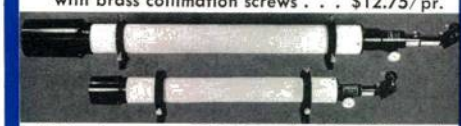


Photo-Guide Telescopes 2.4" & 3.1"

Coated, air-spaced objectives. Each telescope includes diagonal prism and Ke 9mm cross-hair eyepiece.

2.4" Guidescope . . . . . $ 58
3.1" Guidescope $129
Cast aluminum guidescope mounts with brass collimation screws . . . $12.75/pr.



Write for your 1974 Catalog. In U.S. and Canada enclose 30¢ coin or stamps for postage. Elsewhere, send US $1.00 or equivalent.

ORTHOSCOPIC EYEPIECES 1¼" OD True 4-element design. Uncompromising quality. 4, 6, 9, 12.5, 18, 25mm each . . . . . $18.75 ppd.

KELLNER EYEPIECES 1¼" OD High performance at economical price. 6, 12.5, 25 mm each $11.75 ppd. 40 mm each $14.75 ppd.

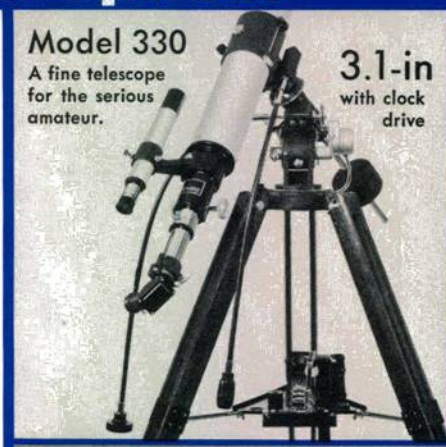
MEADE *orthoscopic eyepieces, 8x50 viewfinders and photo guide telescopes are used on many of the finest instruments, such as Cave* ASTROLA *reflectors.*

.965" OD Eyepieces

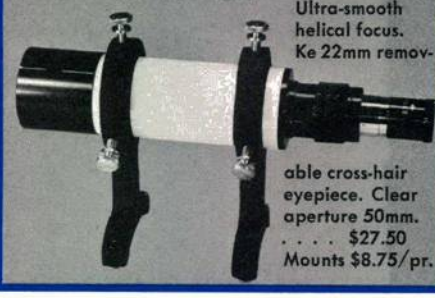
Fine quality. For all imported telescopes. Adapter converts to 1¼" eyepiece holders.

H 6mm, H 9mm, H 12.5mm $10.95 ppd.
SR 4mm, Ke 22mm . . . . $12.95 ppd.
AH 40mm . . . . . $14.95 ppd.
Ke 9mm with crosshairs . . $14.95 ppd.
Machined adapter converts eyepieces to 1¼" OD . . $ 4.00 ppd.

Model 330 3.1-in
A fine telescope for the serious amateur. with clock drive



8x50 Viewfinder
Ultra-smooth helical focus. Ke 22mm removable cross-hair eyepiece. Clear aperture 50mm. $27.50
Mounts $8.75/pr.



WHOLESALE DIRECT-MAIL SHOWROOM

MEADE INSTRUMENTS

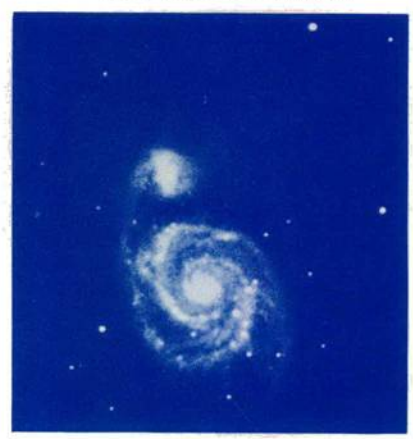
721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281

COAST NAVIGATION SCHOOL offers the first home-study courses written for the amateur astronomer. This well-organized, two part program consists of a series of fast-moving, profusely illustrated and clearly written lessons which enables you to learn this fascinating subject easily without any additional textbooks. The entire two-part program may be completed without a telescope. Personalized, individual attention is given every student.

ACCREDITED MEMBER
NATIONAL HOME STUDY COUNCIL

MORE THAN EVER BEFORE MAN'S ENVIRONMENT INCLUDES THE UNIVERSE

Your curosity about the heavens is the first step to knowledge of the universe.



★ **VISUAL ASTRONOMY:** An exciting course for beginners in 10 lessons.

★ **TELESCOPIC ASTRONOMY:** A fascinating 18 lesson course for advanced students.

SPECIAL PRICES on Telescope and Course combinations. Nationally known Schmidt-Cassegrain and Reflector Telescopes available.

Coast Navigation School SCHOOL OF ASTRONOMY

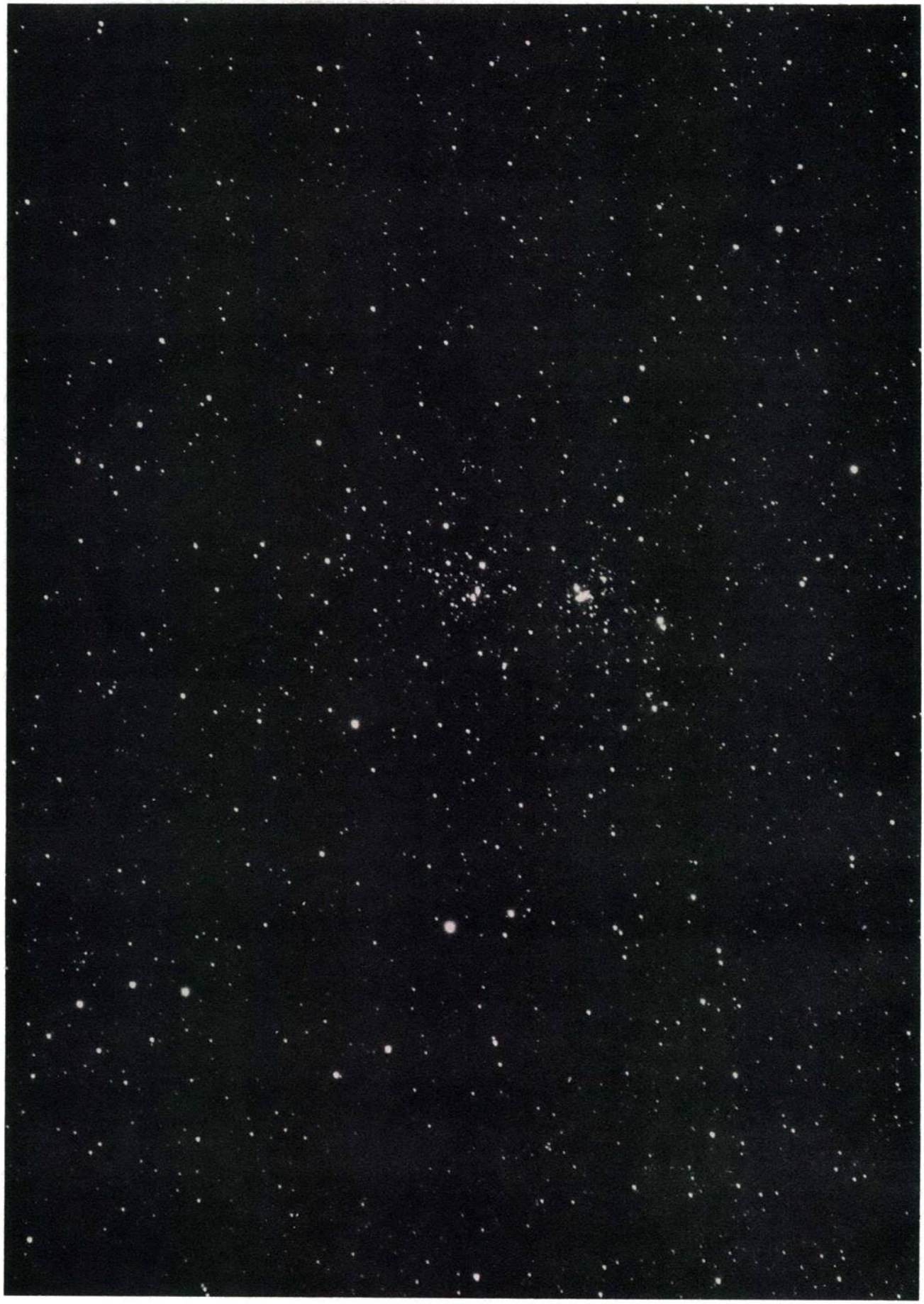
DEPT. 5363 418 EAST CANON PERDIDO / DRAWER Y / SANTA BARBARA, CALIFORNIA 93102

PLEASE SEND ME YOUR INFORMATION PACKAGE TODAY

NAME_____

ADDRESS_____

CITY_____ STATE_____ ZIP_____



Photograph by John Gorka

Photography With Small Telescopes

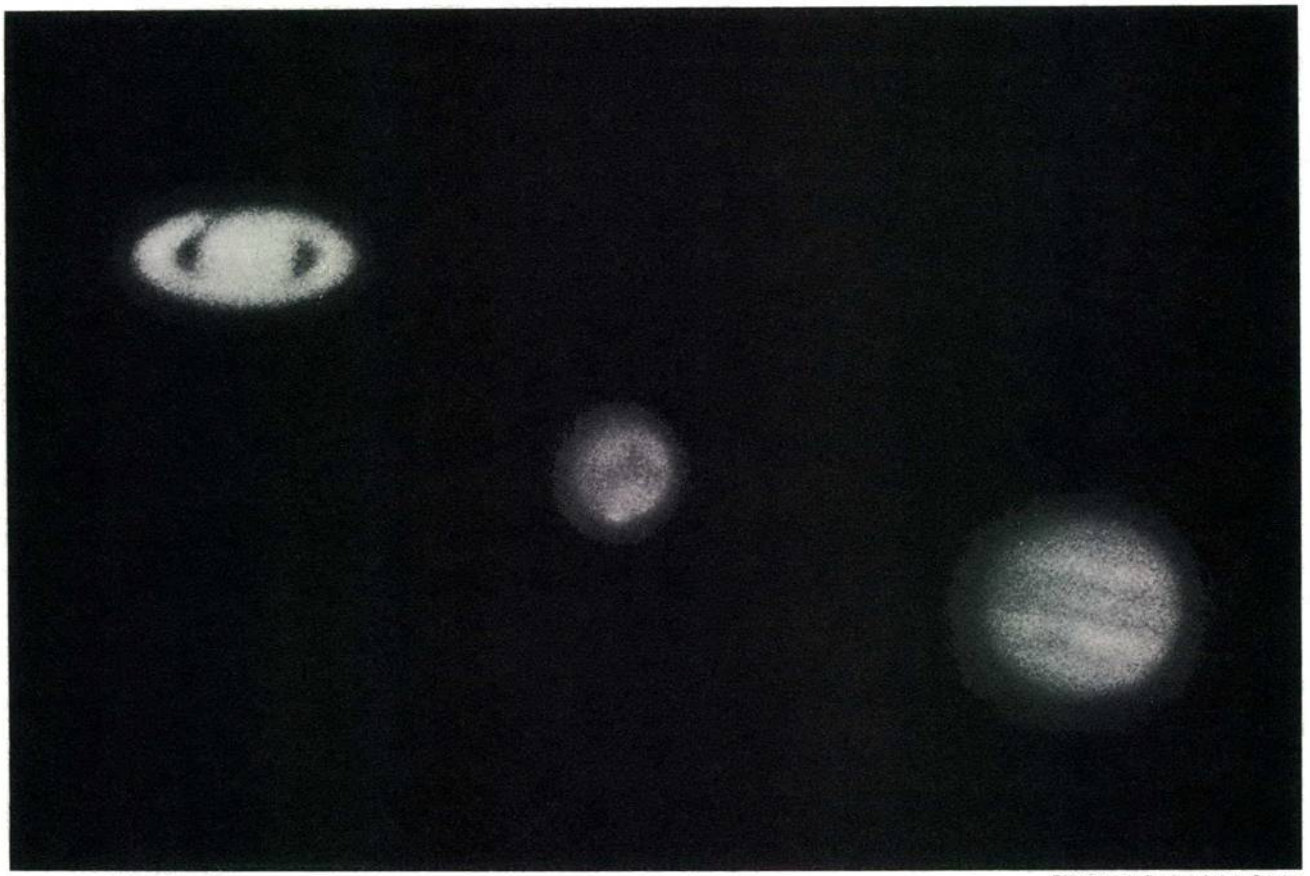
by
John C. Gorka

It is easy to assume that capturing beautiful sky portraits is simple because so many people have successfully taken stunning pictures of planets, star clusters and even very faint nebulae and galaxies. But what many enthusiasts fail to realize is that the really beautiful pictures

The double cluster in the constellation Perseus is located about midway between the brighter stars of Perseus and Cassiopeia. To the unaided eye they are a faint patch, but a small telescope will show all the stars seen in this 2-1/2 minute exposure on Tri-X film. A 300mm telephoto lens and camera combination was attached to the author's 4-1/4 inch reflector, used for guiding. The picture shows stars to 10th magnitude. Each cluster contains about 300 stars within a radius of 50 light-years. Recent determinations have revealed the brighter cluster (right, known as h Persei) is about 7000 light-years away, 1000 light-years closer than its companion (Chi Persei). ←

Small telescopes can be used to make fine portraits of a variety of celestial subjects. The lunar eclipse of Feb. 9, 1971, was photographed at the prime focus of a 3-1/2 inch Questar telescope on GAF 500 film. The lower part of the moon is darkest because it is near the center of Earth's shadow. Sunlight more easily refracts through Earth's atmosphere at the edge of the shadow. In this eclipse that edge is the upper portion of our satellite. →

Photograph by Conrad Kussner



Photographs by John Gorka

Even a 4-1/4 inch telescope is capable of photographing detail on the planets as these photos demonstrate. All were taken using the afocal system with a 9mm eyepiece. The Saturn picture is a three second exposure on Tri-X taken in 1971. In the same year the author caught Mars, in a moment of good seeing, with a 1/2 second exposure on Plus-X film. Syrtis Major is the main dark feature on Mars. Also visible is the white, south polar region. Jupiter, showing the red spot, is a one second exposure on Tri-X on Sept. 2, 1973.

come only after many repeated failures.

Although quality equipment is a prerequisite for good results, the word "quality" does not necessarily imply large size or high cost. Anyone who has had some experience with telescopes understands that a well made six inch reflector is superior to a poorly made 10 inch scope.

For most beginners the main concern is cost, so a small telescope is usually the first choice; many beautiful pictures have been taken with instruments smaller than a six inch reflector.

Here is a short list of the basic equipment used to take the pictures illustrating this article: a 4-1/4 inch Newtonian reflector with clock drive made by the Edmund Scientific Company; a 35mm SLR camera with a 58mm f/2 Zeiss lens; a 300mm telephoto lens with 2-1/4 inch clear aperture; a camera mount, and a counterweight.

Naturally, cooperative weather is as important as quality equipment. Clear skies in many areas of the country are rather rare, and good seeing is unpredictable. With a small telescope even the slightest breeze is also a problem because it can easily shake a light instrument. A good site for picture taking is always of prime consideration. Complete darkness, although preferable, is not as essential as the beginner might think. Finding a firm foundation for the telescope such as a concrete sidewalk or driveway can prove to be far more important.

The telescope should have at least 15 minutes to adjust to the outside temperature before pictures are taken. This short wait will help steady the images of the objects being photographed. (This practice applies equally to visual observing with most telescopes.)

For the planetary pictures shown here, the **afocal** system of taking photos was used. For this method the camera is mounted on the telescope with its lens pointing directly at the eyepiece. The camera lens is then set at infinity and the f/stop set at its widest aperture. Any small space that is left between the lens and the eyepiece can be covered with dark paper to prevent

stray light from interfering. With the added weight of the camera on one end, a similar weight must be attached to the other end of the tube for balance. If this is not done, the clock drive may not operate properly in guiding the telescope and keeping it pointed at the desired object.

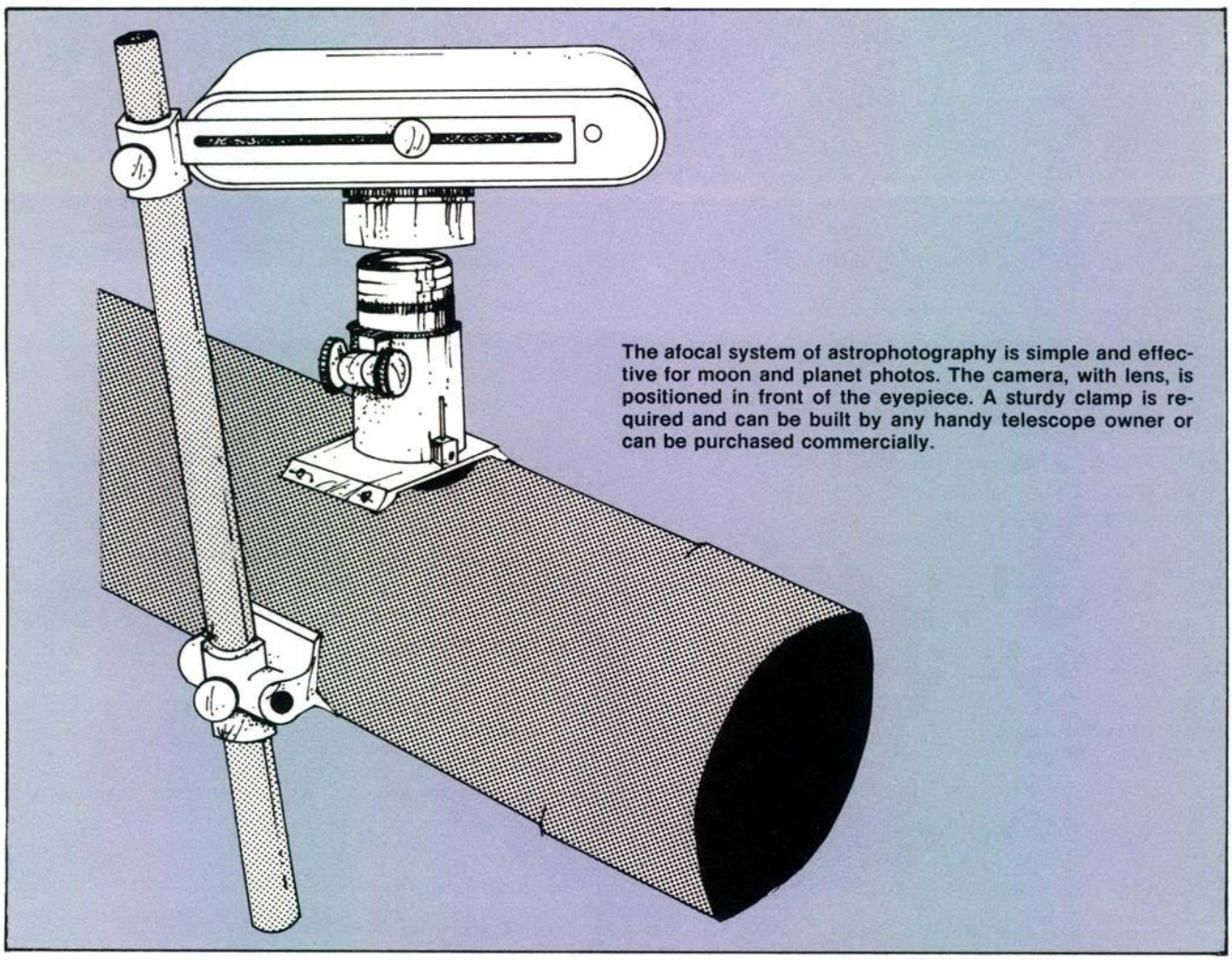
The afocal system is limited in that only bright objects like the moon and planets can be brought to a sharp focus on the camera's ground glass. However, high magnifications are easily obtained and this is especially important when photographing the planets.

Once the desired object is in focus and the clock drive is running, one detail remains. Even with fast film such as Tri-X, exposure times are still relatively long. The camera must have a cable shutter release with locking device to keep the shutter open for the time required — usually one to five seconds for the brighter planets.

Before the shutter is opened, however, the front end of the tube must be covered with dark paper or cardboard to block off the incoming light rays. After the camera shutter is opened,

Photograph by John Gorka

The Orion nebula, a favorite of astrophotographers, is seen here in a three minute exposure on Tri-X. (Same set up as photo on page 52.)



The afocal system of astrophotography is simple and effective for moon and planet photos. The camera, with lens, is positioned in front of the eyepiece. A sturdy clamp is required and can be built by any handy telescope owner or can be purchased commercially.

Photograph by Conrad Kussner

Venus appeared about 20 percent illuminated, as shown here, in early January and again in late February this year. This Kodacolor photo was taken by the eyepiece projection technique through a 4-1/4 inch reflector. The month of March is the last chance this year for photography of the crescent Venus.

wait at least 15 seconds and preferably longer before removing the paper covering the tube opening. This 15 second or longer wait allows all the vibrations of the telescope and camera to stop before the exposure is made. At high magnifications even a slight tremor will blur the image on the negative. Approximate exposure times of from 1/2 second to 10 seconds or more can be made by simply counting the seconds or looking at a watch. The correct exposure for each planet is obtained only by trial and error since equipment and seeing conditions will vary widely. If a light breeze should arise during the actual exposure, the picture will probably be ruined.

Making several exposures of different lengths is the safest way to insure at least one good negative. Although some "experts" say it is impossible, even a 4-1/4 inch reflector will show some planetary detail with inexpensive films such as Tri-X or Plus-X. The only "trick" is in having superior optics for the telescope and a sharp camera lens. As for eyepieces, well made orthoscopics or Kellners will give excellent results.

Slow motion controls for the clock drive should not be needed for exposures under 10 seconds if the telescope's drive is a good one. If the exposures are longer such as for photographing star clusters or nebulae, the afocal system is no longer desirable. The telescope should be used merely to guide, and the camera should have a telephoto lens with a large aperture to do the actual picture taking. The Orion nebula and double cluster photos were taken by this latter method.

Small telescope owners should be aware that although limited, they are by no means restricted from the realm of astrophotography as the photos here demonstrate.

6" SOLAR-SKREEN (in a cell)

DO NOT LET

SOLAR-SKREEN'S™

LOW PRICE FOOL YOU—

IT PRODUCES SAFE, HIGH-QUALITY, FULL-APERTURE SOLAR IMAGES

SOLAR-SKREEN's mirror-like vacuum-deposited aluminum surfaces stop 99.999% of the sun's heat before it enters the telescope. This filter permits superior views of sunspots and solar granulation.

SOLAR - SKREEN FILTER ONLY

3" or less *$6*; 1/2" QUESTAR or 4-1/4" *$8*; 5" CELESTRON or 6" *$10*; 8" *$14*; 10" *$18*; 12-1/2" *$24*; other sizes available.

SOLAR - SKREEN FILTER and CELL ASSEMBLY

(Mounts in seconds no machine work needed)

3" UNITRON *$21*; 3-1/2" QUESTAR *$26*; 4-1/4" (4-7/8" I.D. tube *$27*; 4" UNITRON or 5" CELESTRON *$33*; 6" (6-7/8" I.D. tube) *$34*; 8" CELESTRON or DYNAMAX *$44*

YOU CAN'T LOSE WITH OUR MONEY BACK GUARANTEE --- SHIPPED POSTPAID IN U.S.A.

ROGER W. TUTHILL

11 Tanglewood Lane, Box 1086 CC Mountainside, N.J. 07092

SEND FOR FREE CATALOG

PLANNING TO MOVE?

Let us know **8 weeks in advance** so that you won't miss a single issue of **ASTRONOMY.**

Attach old label where indicated and print new address in space provided. Also include your mailing label whenever you write concerning your subscription. This way, you can help us serve you promptly.

Write to: ASTRONOMY, Circulation Services, 1726 N. 1st St., Milwaukee, Wisc. 53212.

Provide the following information:

_____**Change Address**
_____**Extend New Subscription**
_____**Enter New Subscription**

_____1 Year — $12.00
_____2 Years — $22.00
_____3 Years — $30.00
_____Payment Enclosed
_____Bill Me Later

If you have no label handy, print OLD address here.

Name
Address
City
State Zip

Print NEW address here.

Name
Address
City
State Zip

easily locate any celestial object

SIDEREAL TIME
ANYPLACE — INSTANTLY — ACCURATELY

ACCU Star

★ Whether you are a begining amateur or an advanced astronomer, to find any object in the sky, you must convert your local time to siderial time units

★ Accustar does it quickly without paper and pencil. Accustar teaches you how to use your telescope's setting circles. Locate any celestial object easily! Enjoy astronomy more!

★ Accustar is used by observatories, universities, and astronomers throughout the world.

Each Accustar package contains: the basic Accustar instrument with constellation star chart, Sky-Finder overlay, and the Accustar 90 page text book containing a wealth of information on time, star location, planets, and other celestial objects. Accustar is a scientific instrument built to give you years of service. Order yours today!

$11.95 ppd.

Optics Cleaner

Stop rubbing your optical lenses! Let Omit's 2500 powerful jets blow away dust, grime, lint, etc.

Perfect for use around telescopes, and delicate optical instruments.

$2.75 ppd.

Astronomy Books

NORTON'S Star Atlas - - - $7.50
MAKING YOUR OWN TELESCOPE - - - - - - - - - - - - - - - $4.50
PICTORIAL ASTRONOMY - - - - - - - - - - - - - - - $10.50
OUTER SPACE PHOTOGRAPHY - - - - - - - - - - - - - - - $7.25
FRANK'S Book of the Telescope - - - - - - - - - - - - - - - -$1.75

Focusing mount

A quality focusing mount for telescopes. Helical rack and pinion fits any size tube. For 1-1/4" O. D. eyepieces. Adjustable tension.

$10.90 ppd.

FREE
Optics Catalogue

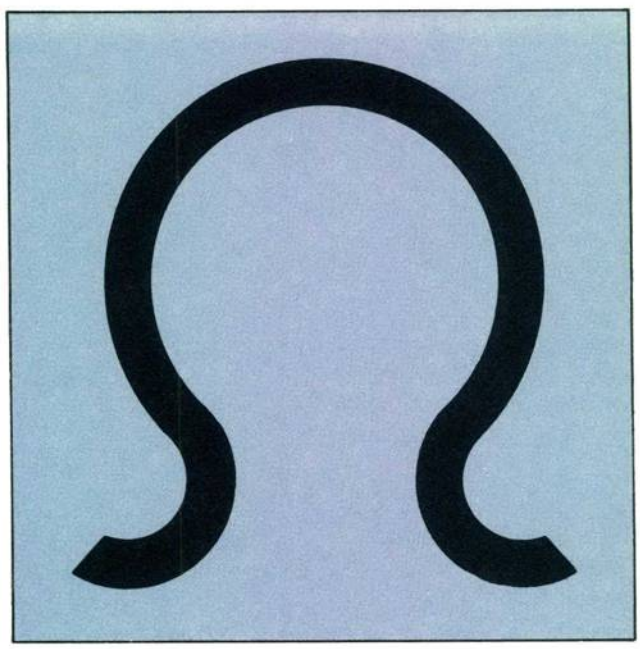
Free color catalog listing telescope making kits, accessories, books, eyepieces, etc. Get yours today!

University Optics Inc. BOX 1205-A 2122 E. Delhi Ann Arbor, Mich. 48106

CONSTELLATION CLOSE-UP

LEO

by
Thomas C. Bretl



While winter skies abound with beautiful open clusters and the summer Milky Way offers endless star fields and diffuse nebulae, Leo the Lion ushers in the spring constellations, rich with distant galaxies. Although there are good double and variable stars to be found and an annual meteor shower to watch for in November, it is Leo's extragalactic offerings which are of greatest tele-

scopic interest.

Halfway between Theta (70) and Iota Leonis, M-65 and M-66 are close enough together to fit within the same low power field of view. And although neither of these spirals reveals any structural detail in a small telescope, both are bright enough to be easily seen through a four inch instrument. Compare their magnitudes, shapes and sizes for yourself. M-66 should appear brighter, but although each has been described as having the same elongated shape, M-65 may appear to be the rounder of the two. (On the chart each galaxy has two designations: the M number and the NGC number. These are simply two different catalogs of nebulae and galaxies, and bright objects are listed in both.)

The second group of galaxies is located about nine degrees east of Regulus in a seemingly blank area of the constellation, and is high lighted by the three Messier objects M-95, M-96 and M-105. Several other fairly prominent galaxies can be found in this area, and all lie within several degrees of each other.

Like M-65 and M-66, M-95 and M-96 fit comfortably within the same low power field of view. They seem less conspicuous than the previous pair, but their listed magnitudes are the same — 10th and 9th respectively. M-95 is small and round,

TABLE OF OBJECTS IN LEO

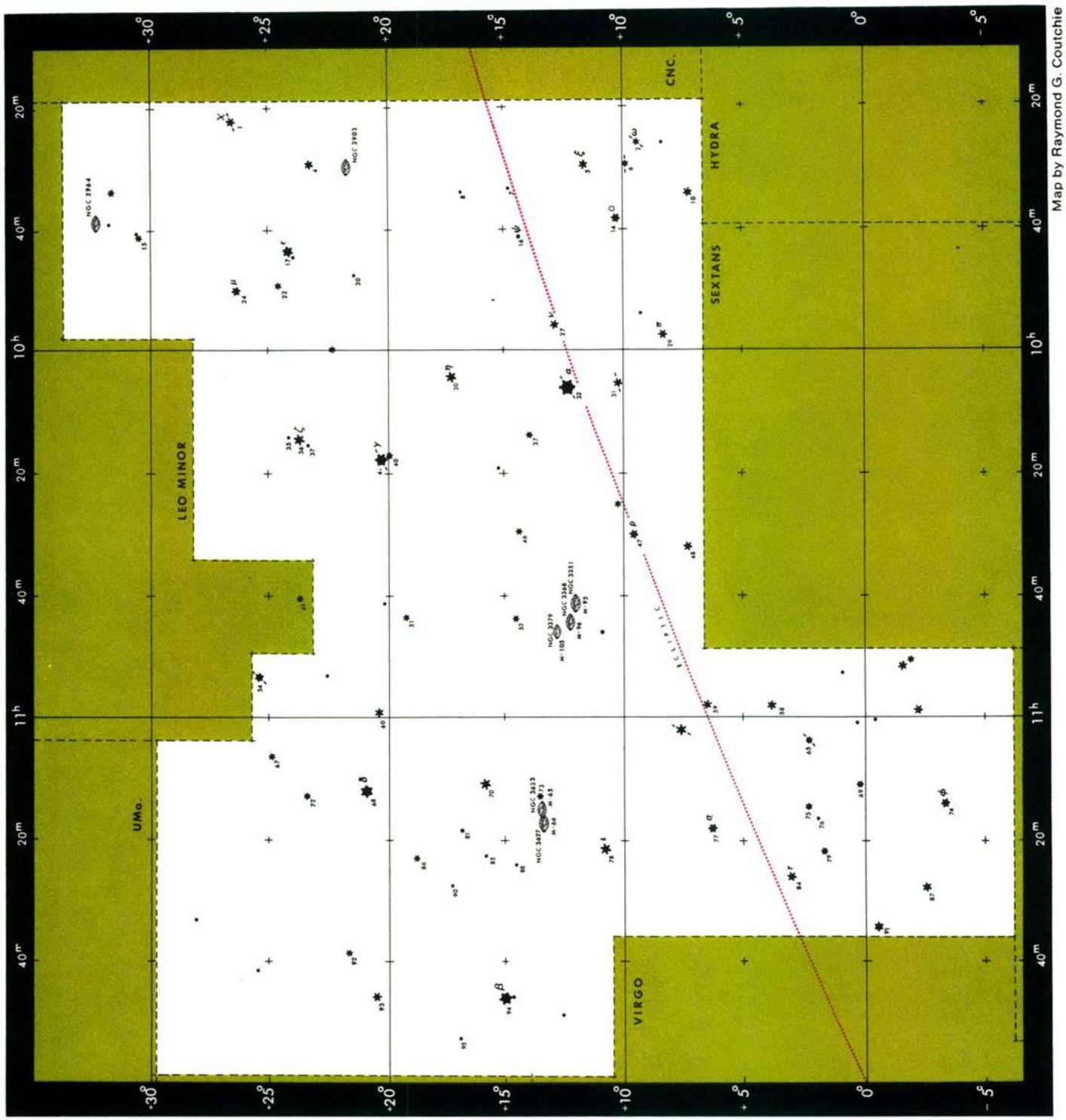
Galaxies

NGC	Messier Object	Mag.	Size	R.A.	Dec.
2903		10		9^h30^m	+21°38'
3351	M-95	10	3' x3'	10^h42^m	+11°52'
3368	M-96	9	7' x4'	10^h45^m	+11°59'
3379	M-105	10	2' x2'	10^h46^m	+12°45'
3384		11	4' x1'	10^h46^m	+12°45'
3412		10	2' x1'	10^h48^m	+13°35'
3521			6' x45"	11^h04^m	+00°08'
3593		11	2' x1'	11^h13^m	+12°59'
3623	M-65	10	8' x2'	11^h17^m	+13°17'
3627	M-66	9	8' x2'	11^h19^m	+13°10'
3628		10	12' x2'	11^h18^m	+13°47'

Double Stars

Star	Mag.	Sep.	Color	R.A.	Dec.
6	5.0 - 9.5	37"	Gold-azure	9^h30^m	+9°52'
δ	2.6 - 3.8	4.3"	Yellow-green	10^h18^m	+20°00'
54	5.0 - 7.0	6.3"	Gr. white-blue	10^h54^m	+24°54'
88	6.4 - 8.2	15.4"	Yellow-blue	11^h30^m	+14°32'
90	6.0 - 7.3 - 9.0	3.4"-63"	White-blue white	11^h33^m	+16°58'

Epoch 1970



Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula Double Stars Variable Stars ○

Galaxies Planetary Nebula ○ Open Star Clusters ☆ Globular Clusters ⊛

while M-96 is larger and slightly elongated. Just north of M-96 is M-105, a small elliptical galaxy which has a fuzzy starlike appearance under low magnification.

In observing all of these objects, you should keep in mind that a galaxy's magnitude is only an estimate of total brightness (different sources often list different magnitudes) and so is only one factor determining overall "visibility". A galaxy's size and shape and the uniformity of its brightness also greatly affect the ease with which it may be seen through a small telescope. It is therefore difficult to predict which of these galaxies will appear best as seen through your telescope, and through your eyes.

Along with the galaxies, two individual stars in Leo deserve special mention, Algieba (Gamma Leonis) and R. Leonis. Situated about five degrees west of Regulus (Alpha Leonis), R. Leonis is a long period variable star. A red star of spectral type M, its magnitude fluctuates between 4.4 and 11.6 over a period of 313 days. This month it is near minimum brightness. Webb (in **Celestial Objects for Common Telescopes**) describes it as one of the finest of its class, having an especially conspicuous color that is in striking contrast to that of nearby stars.

Algieba, Leo's most beautiful double star, is also known for its color. Its components, at a separation of 4.3 seconds of arc, are yellow and green. The brighter one shines at magnitude 2.6, the companion at magnitude 3.8. Look for it in Leo's sickle-shaped "mane" that extends to the north from Regulus.

Even for the naked eye observer, Leo holds a definite appeal. Its stellar patterns are so clear and suggestive that it has retained its name throughout recorded history. But then to see a lion there is easy — it is the telescopic view which demands so much from our imaginations. For although Leo is not privileged to shine with the brilliance of Orion or have the Milky Way flow silently across its boundaries, when we look toward Leo, we can look far beyond its member stars. It is here that we can look out of our own home Milky Way, through the vast and empty space around it, to places 10,000 times farther than all of Leo's twinkling stars — where whole new galaxies are found.

They have been there for millions of years, but unseen and unknown by the men who first called those stars "the Lion".

PUBLISHER'S MEMO

It looks like Letters to the Editor is "In Focus" from now on. The letters contest winner is David Stein, a 53 year old astronomy enthusiast from Long Valley, N.J. He is a mechanical engineer working for the United States Army, and his immediate astronomy plans are to build a backyard observatory which will house a 14 inch telescope. Mr. Stein has already received his $25 prize.

ASTRONOMY received about 1000 entries in our Letters to the Editor Naming Contest. And wouldn't you know, it was the simplest and most to-the-point name that won. There were many other interesting submissions, the majority being prefixed with "Astro-" — "Astro-Briefs" was perhaps the most humorous in this group, conjuring up mental images of a rather unique specialty undergarment.

One surprising entry was abruptly to the point: "Now Listen Here Pub..." and it nearly won concensus vote. Another entry, "Forum and Againstum" conjured warm and sanguine feelings in us. But "In Focus" was the most terse and suitable for ASTRONOMY magazine.

Turning to another arena for a moment, we conducted a survey recently on ASTRONOMY's audience, and the results will be published in a future Publisher's Memo. Thank you for your very enthusiastic response and let me assure you the information you sent us will only be used in a statistical manner to aid us in future directions of ASTRONOMY. Since names were removed from the survey as they came in, we frankly have no way of knowing which subscriber sent in what information.

The last two months have been a very busy time for ASTRONOMY, and with this issue ASTRONOMY welcomes more than 14,000 new subscribers throughout the United States and Canada. We hope you enjoy the magazine and look forward to having you with us as we grow — and that leads me to another interesting point.

Say there, readers! How would you like to help ASTRONOMY's circulation grow? You see, the more circulation we have the sooner we can add more pages to the magazine. We already have 30,000 subscribers, but as soon as we hit 40,000 ASTRONOMY will grow instantly fatter to 80 pages. And you — each and every one of you 30,000 loyal subscribers — can have a hand in helping us grow. You will not only benefit by getting a healthy 80 page magazine but you can also get....

But I like suspense! Toward the end of March look for a special letter from us and keep your eyes peeled for the April Publisher's Memo. We will tell you about our Circulation Contest and how three of our subscribers can win $$$.$$. We will also tell you how each and every subscriber can earn something (?) and at the same time help our circulation grow, so we can add 16 more pages to ASTRONOMY.

Stephen A. Walther

Stephen A. Walther
Publisher

Engineered For The Last Word In Breathtaking Performance... Priced For First Choice In Value... Fully Equipped With Many Extra Features!

You'll Marvel At How The Superb Optics Of This Portable

6-INCH RV-6 DYNASCOPE®

Including... • *ELECTRIC DRIVE (Patented)* • *SETTING CIRCLES* • *ROTATING TUBE*

A Complete Instrument, No Costly Accessories Needed!

Model RV-6 Complete with Dyn-O-Matic Electric Drive and All Features Described Below

$219.95

f.o.b. Hartford, Conn.
Shipping Wt. 77 lbs.
Express Charges Collect
$15 Crating Charge

Give The Same Exquisite Definition As Far More Expensive Instruments!

This staunch leader of the Dynascope line has won widespread recognition from schools, colleges, and professionals, as an outstanding achievement in a 6-inch telescope. Since it was introduced a few years ago, our files have become filled with complimentary letters from excited amateurs and professionals all over the country. Each one is truly amazed at the superior optical performance of this RV-6 6-inch Dynascope! Here is large aperture in a quality instrument at a price that compares with many 4-inch telescopes. *And this low cost includes such exclusive extra features as electric drive* (patented), *setting circles, and rotating tube!* There are no "extras" to run up your cost!

The superb optical system resolves difficult objects with definition that is absolutely breathtaking. The close tolerances of the precision construction assure an accuracy and smoothness of operation once associated only with the finest custom models. The heavy-duty mount, complete with electric drive, provides the stability so essential for satisfactory viewing, yet there is easy portability, because in a matter of minutes the entire telescope can be dismantled into three easy-to-handle sections.

Only Criterion's engineering ingenuity, coupled with volume production and modern manufacturing methods, makes this handsome 6-inch model available at such reasonable cost. You can order it with complete confidence that it will live up to your expectations in every way, for this assurance is *guaranteed* under our full-refund warranty. Send your check or money order today. Or use our liberal time-payment plan and take months to pay.

Compare Ratings!

Read report by a leading independent consumer service on the various types and makes of telescopes, for very useful information...and see by comparison why the RV-6 is such an extraordinary value.

You Could Pay $100 More Without Getting All These Superior Features (Except on Another Dynascope)

1. EXQUISITE OPTICAL SYSTEM INCLUDES f/8 6-INCH PARABOLIC MIRROR made of **PYREX**-brand glass, accurate to better than 1/10 wave, zircon-quartz coated, and guaranteed to reach the theoretical limits of resolution and definition. Teamed with elliptical diagonal mounted in 4-vane adjustable spider.

2. NEW DYN-O-MATIC ELECTRIC DRIVE with smooth self-acting clutch that engages and disengages automatically as you seek different objects. Will not interfere when manual operation is desired. Safety housed case. Plugs into ordinary AC socket.

3. TWO EYEPIECES: Achromatic Ramsdens **70X** (18 mm.), **140X** (9 mm.). Also available: **100X** (12.7 mm.), **180X** (7 mm.). Achromatic Ramsdens, $14.95 each; **220X** (6 mm.), **320X** (4 mm.). Orthoscopics, $18.50 each.

4. SOLID NEW EQUATORIAL MOUNT, extra-reinforced design to provide pillarlike stability. No annoying side play or wobble. Adjusts easily to any latitude.

5. SETTING CIRCLES for both right ascension and declination. Handsomely engraved and finished in fine aluminum.

6. 6 x 30 FINDERSCOPE, ACHROMATIC, COATED, with accurate cross hairs and fine focus. Durable cast-aluminum bracket with 6 adjusting screws allows positive collimation.

7. ROTATING TUBE FOR MAXIMUM VERSATILITY AND VIEWING COMFORT. Solid-cast chrome-finished rings are generous 1" wide with felt lining. Newly designed construction, with oversized knurled adjusting knobs, affords maximum rigidity and allows quick disassembly and portability, with or without tube.

8. STRIKINGLY HANDSOME WHITE 50" BAKELITE TUBE with porcelainized Duralite finish, durable yet light. Walls are 1/8" thick, completely insulated and anti-reflective blackened inside.

9. BRASS RACK-AND-PINION EYEPIECE HOLDER has precision-cut rack and gear for easier, smoother, more positive focusing. Takes standard 1¼" oculars, negative or positive.

10. STRONG, VIBRATION-FREE, ALL-METAL TRIPOD with easily removable legs. Provides sure, steady support, plus lightweight portability.

Sound too good to be true? Then read what these delighted DYNASCOPE owners have to say:

"A friend of mine has a 6-inch telescope without electric drive, for which he paid, over $300. He agrees that my new DYNASCOPE not only outperforms it, but is a much better-looking and better-built instrument."
J.L.—New York

"Congratulations on the excellence of your workmanship. The optics are truly amazing. I never expected such wonderful performance."
L.H.N.—Massachusetts

Criterion Manufacturing Co.
331 Church St., Hartford, Conn. 06101
Manufacturers of Quality Optical Instruments

Criterion Manufacturing Co.
Dept. AS-16, 331 Church St., Hartford, Conn. 06101

☐ Please send me, under your unconditional guarantee, the RV-6 6-inch Dynascope. Payment of $219.95 plus $15.00 crating charge is enclosed.

☐ Send FREE ILLUSTRATED LITERATURE describing the RV-6 6-inch Dynascope and all the telescopes in the Dynascope line.

☐ Send FREE ILLUSTRATED LITERATURE on your new DYNA-TRACKER™ Variable-Speed Control for RV-6 or other electric-drive telescopes.

Name _____

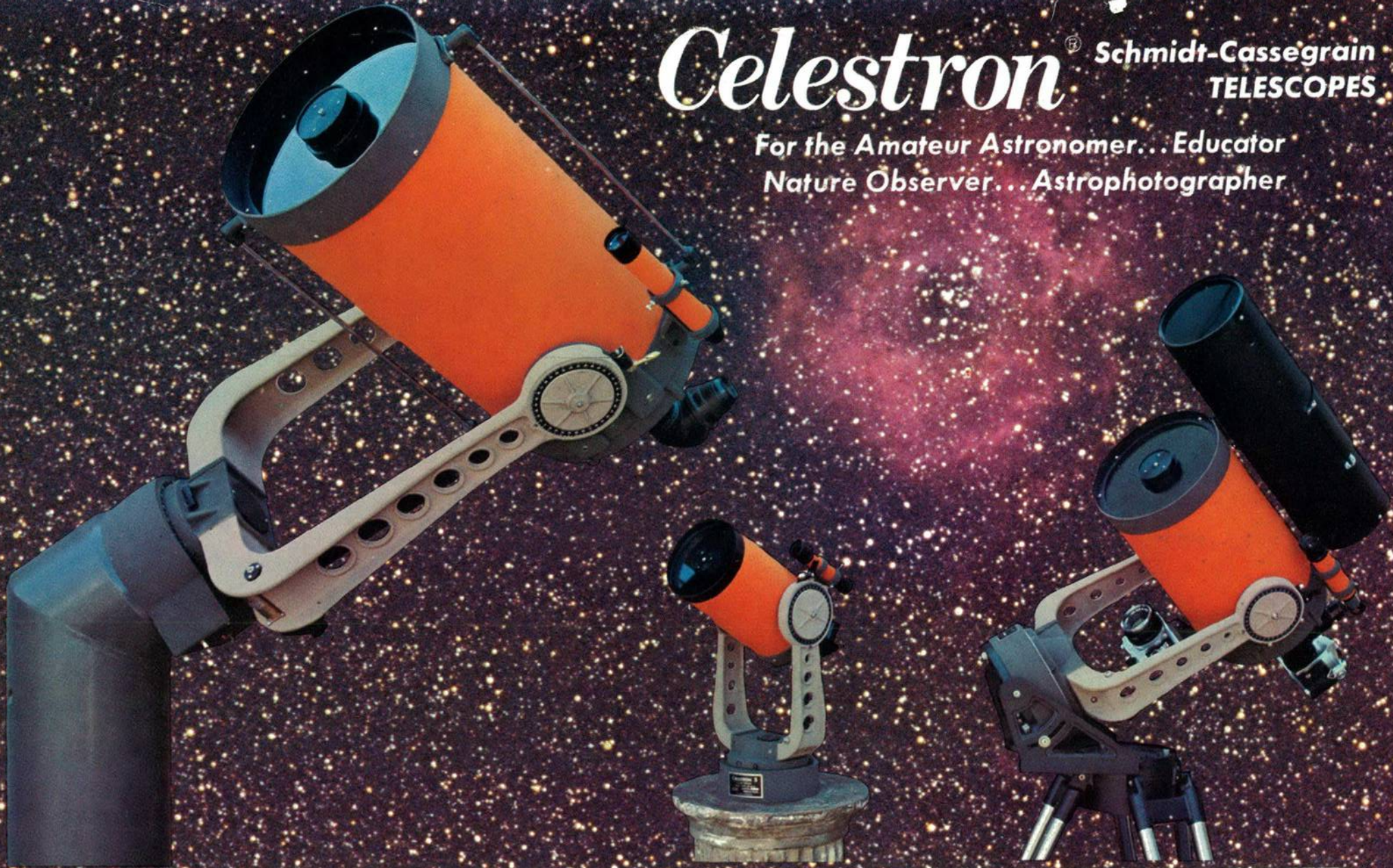
Address _____

City _____ State _____ Zip _____

Celestron®

Schmidt-Cassegrain TELESCOPES

For the Amateur Astronomer... Educator
Nature Observer... Astrophotographer



We Promise You The Moon...

... the polar caps of Mars, the rings of Saturn, the ever-changing belt structure of Jupiter, gossamer nebulae, sparkling globular clusters, and wheeling spiral galaxies. Like you've never seen them before. Free with every Celestron telescope.

In fact, with a Celestron, you'll bring the universe into sharp focus, because a Celestron offers sharper images over a wider flat field than any other commercially available telescope in its aperture range.

It also offers apertures large enough to make high powers really worth using, in a package portable (and sturdy) enough to take into the field or on vacation.

The Schmidt-Cassegrain optical configuration makes it possible. This mirror/lens system optically folds the long focal length of a large mirror inside a short, lightweight tube. Result: an observatory telescope with crisp, brilliant images in a stable, compact portable.

For more information, request our free color catalog.

CELESTRON	5"	8"	14"
Useful Powers	25-300X	50-500X	50-850X
Light Grasp (vs. eye)	188X	510X	1,760X
Resolution (arc secs.)	0.8	0.5	0.28
Weight (lbs.)	12	23	108
Base Price	$625	$895	$3,600

Background Photo — The Rosette Nebula, Celestron 5½-in. Schmidt Camera

Celestron Pacific 2835 Columbia St. Box 3578AM
Torrance, Calif. 90505

Phone L.A.(213)328-9560/N.Y.(212)834-1888/Chi.(815)498-2709